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(continued on next page)

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**E21B 43/10 (2006.01)**

(52) UK CL (Edition X ):  
**E1F FAC FAC9 FLA**

(56) Documents Cited:  
**GB 2374098 A** **EP 1555386 A1**  
**WO 2003/029608 A1** **WO 2000/037766 A2**

(58) Field of Search:  
INT CL<sup>7</sup> **E21B**  
Other: **EPODOC, JAPIO, WPI, TXTE (FULLTEXT)**

(54) Abstract Title: **Mono diameter wellbore casing**

(57) An apparatus 200 for radially expanding and plastically deforming an expandable tubular member 12 comprising: a support member 14, a first expansion device 206 for radially expanding and plastically deforming the tubular member coupled to the support member; and a second expansion device 202 for radially expanding and plastically deforming the tubular member coupled to the support member. A gripping or locking device 16, which may have slips or dogs for engaging the tubular member 12, is also coupled to the support member 14.

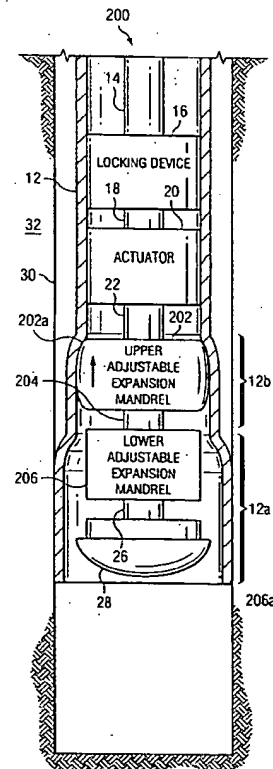


Fig. 20

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GB 2 421 259 A

**GB 2421259 A continuation**

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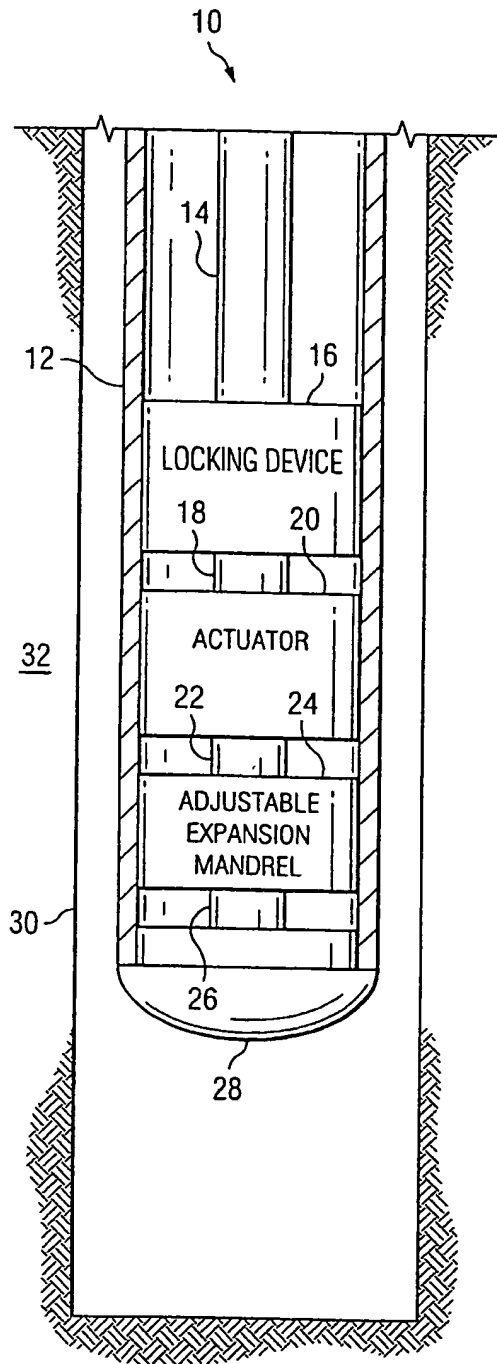


Fig. 1

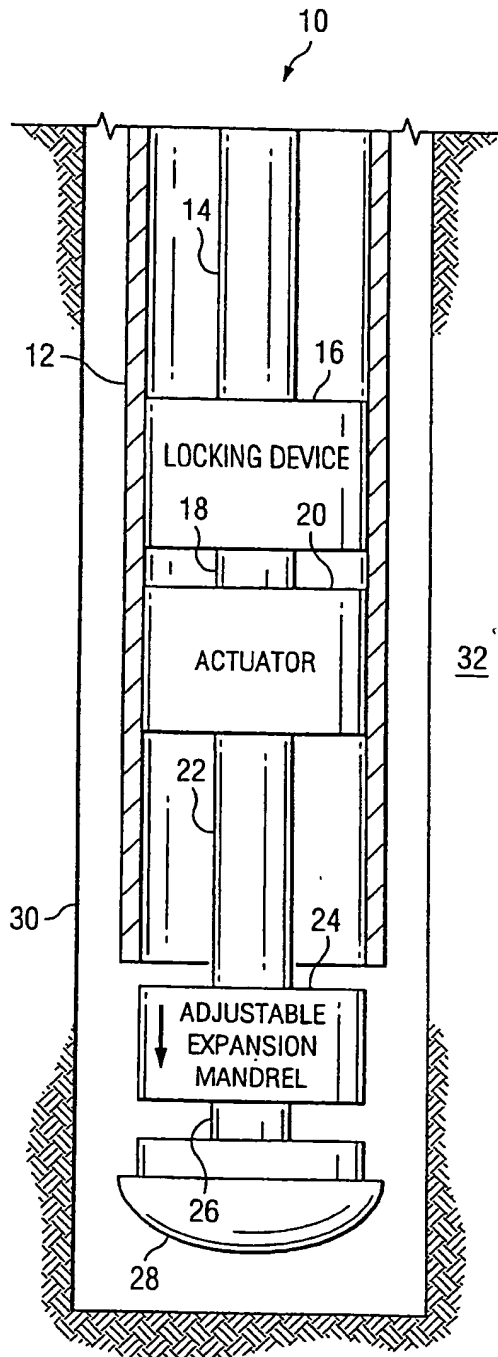


Fig. 2

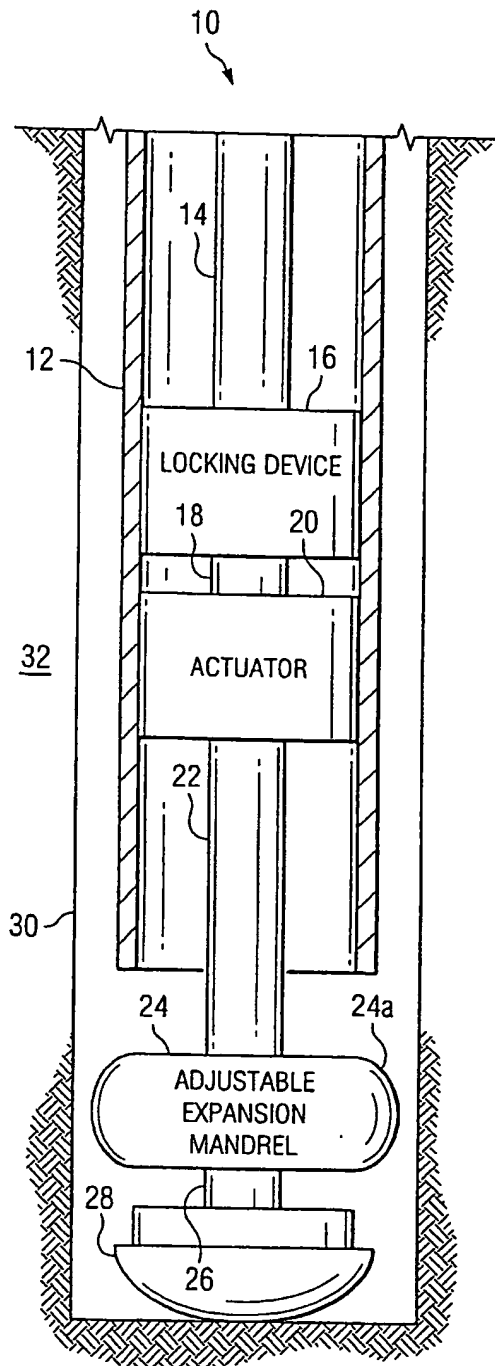


Fig. 3

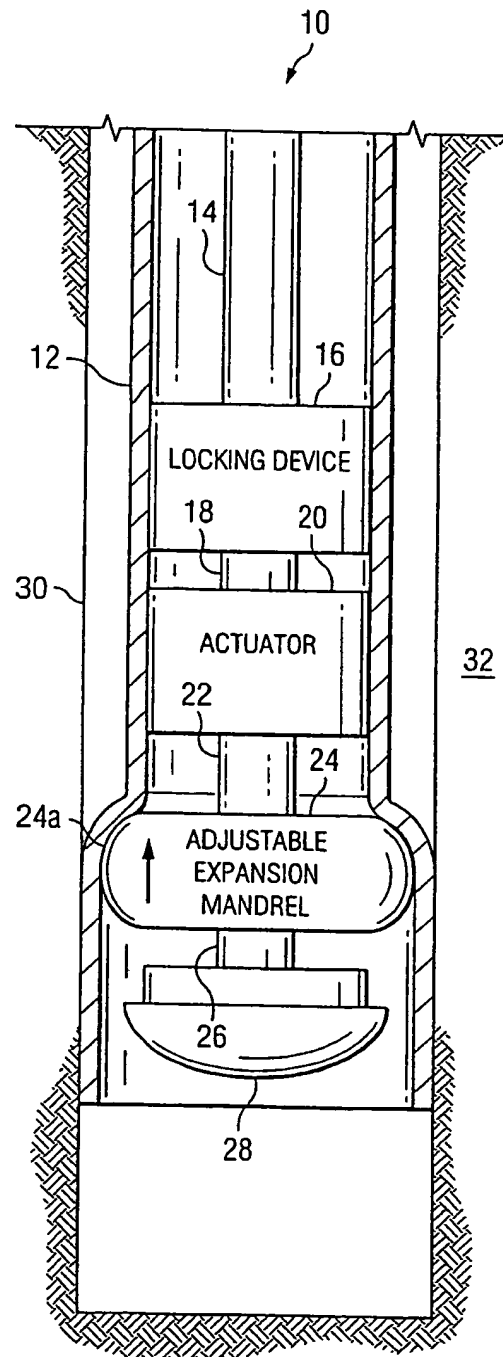


Fig. 4

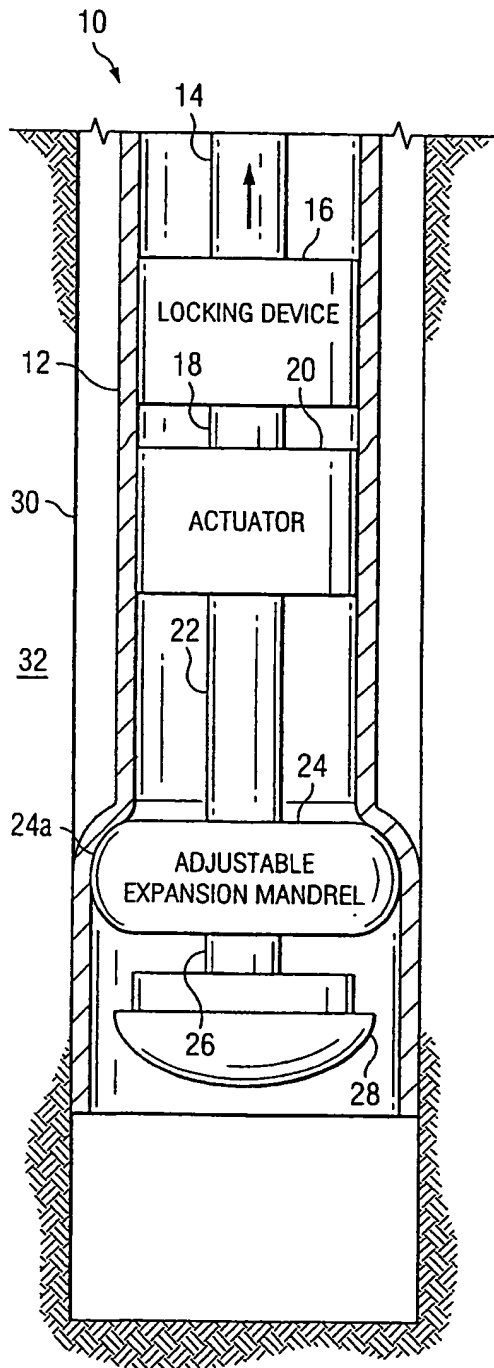


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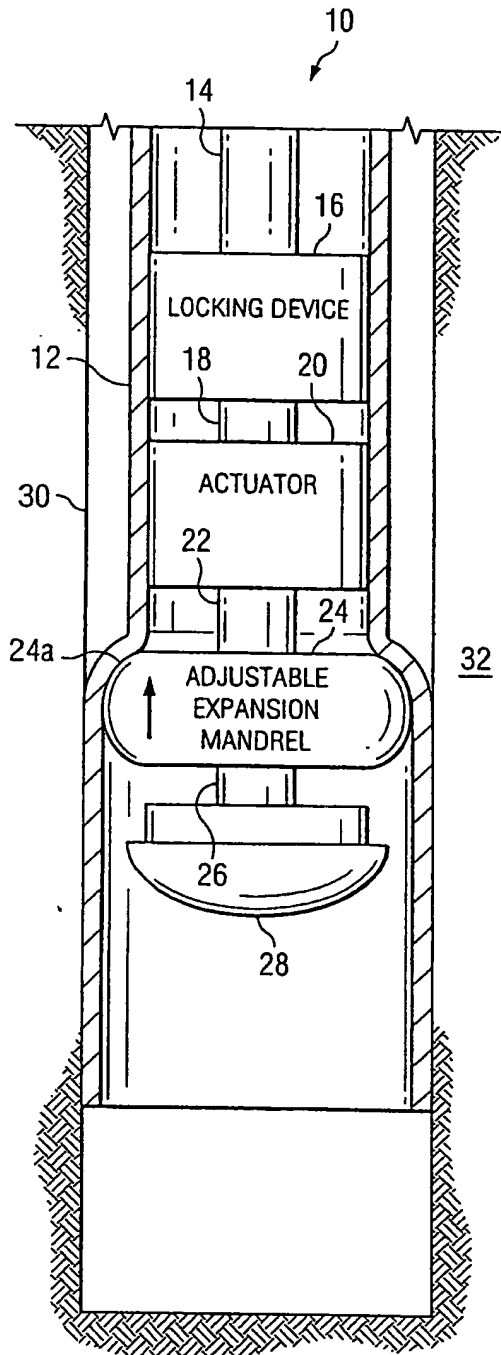


Fig. 6

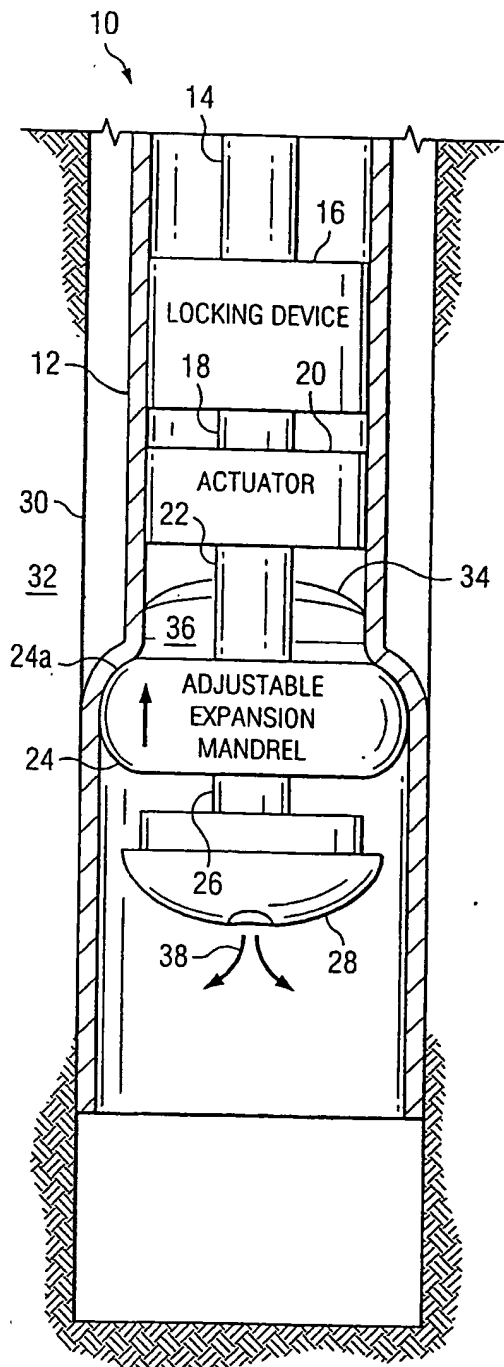


Fig. 6a

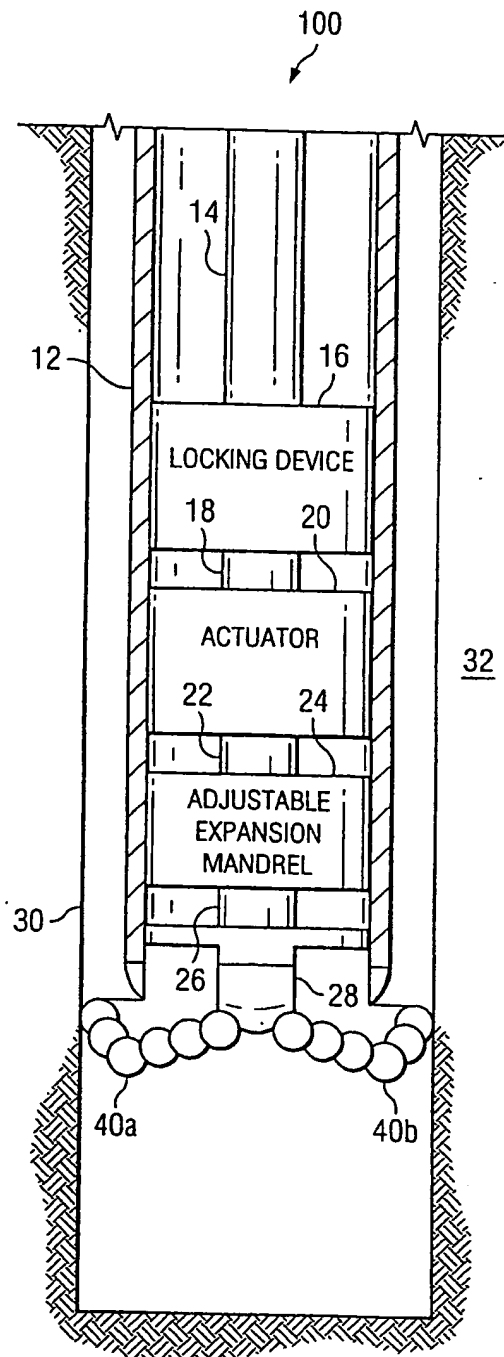


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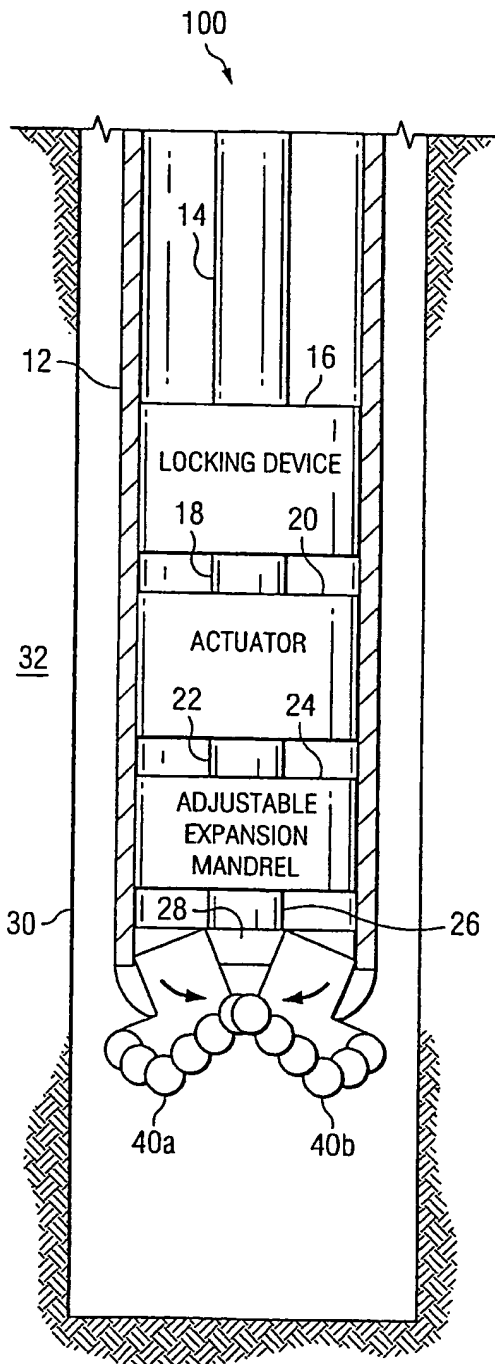


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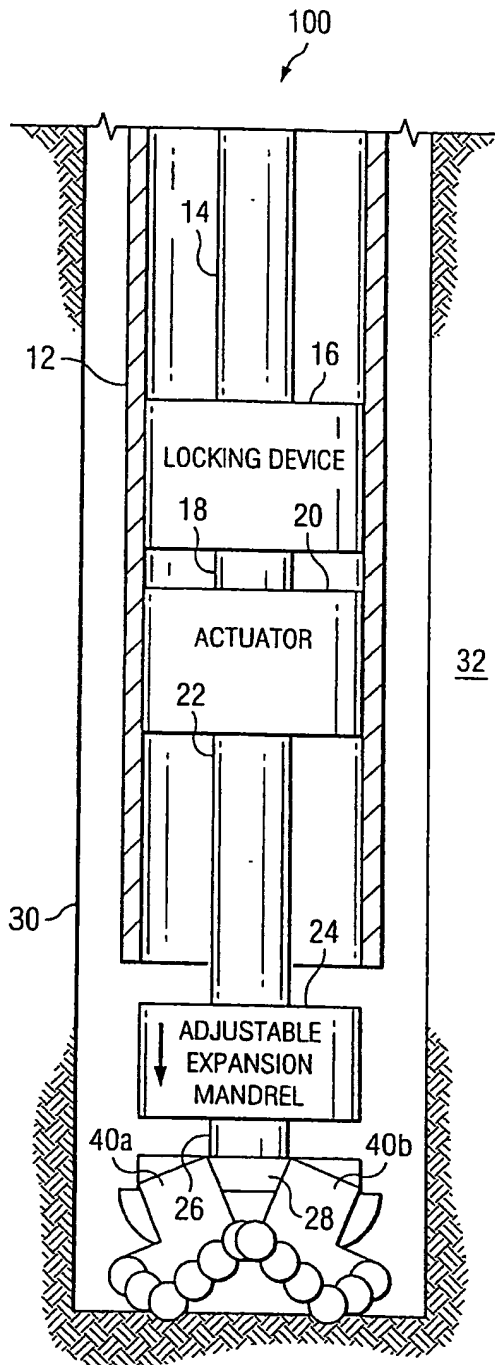


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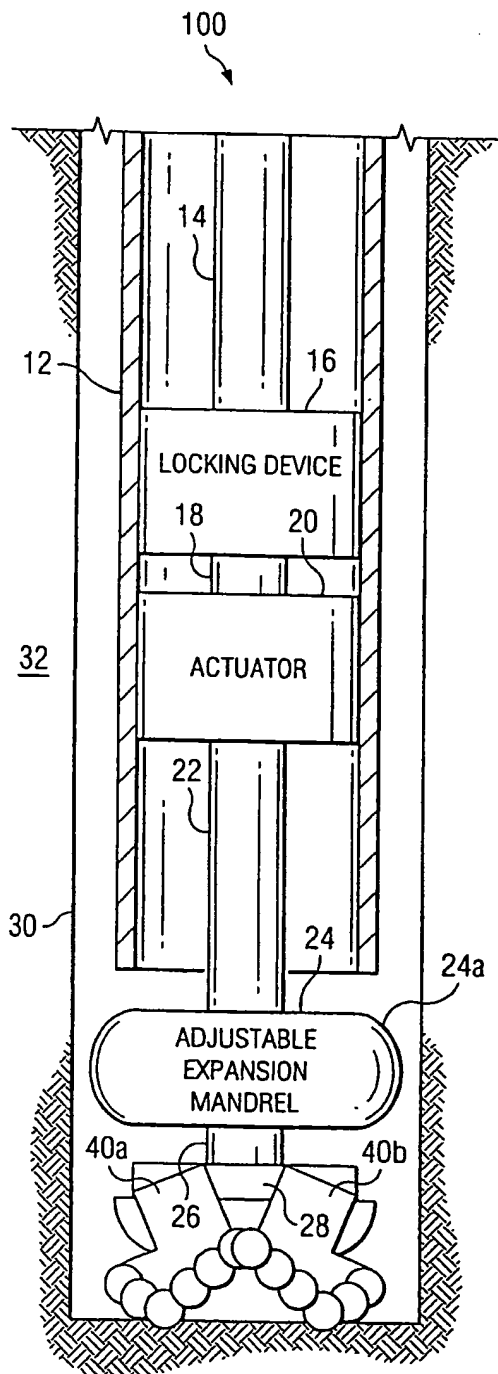


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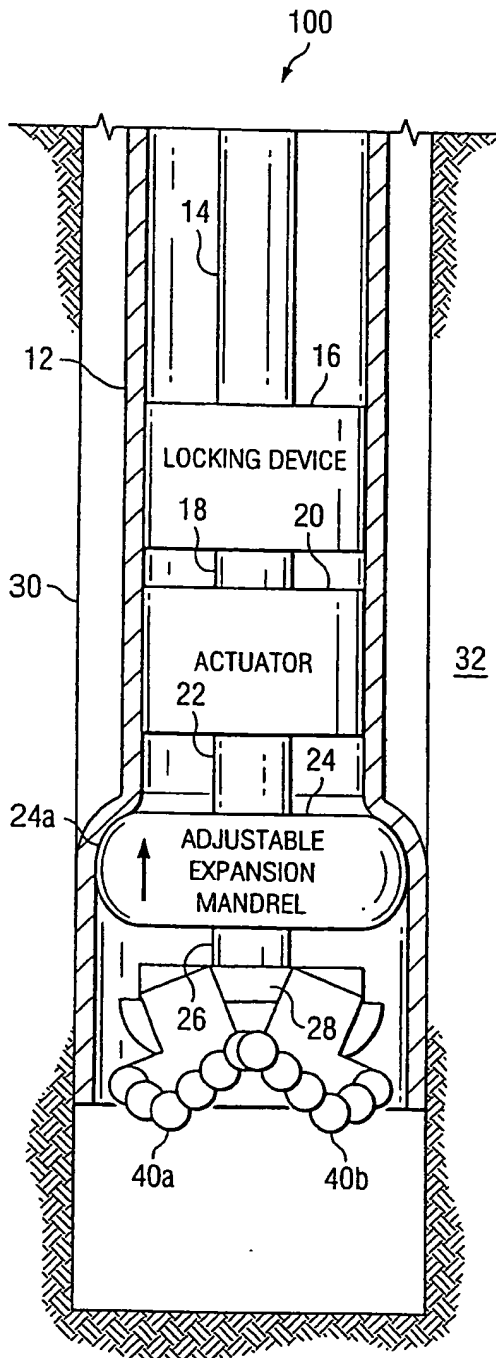


Fig. 11



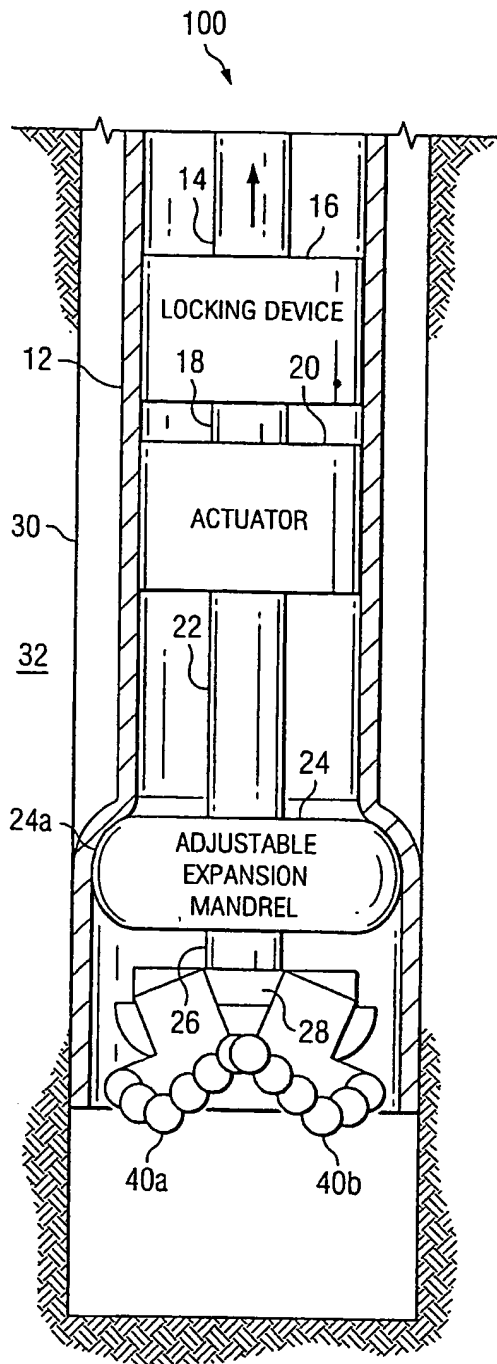


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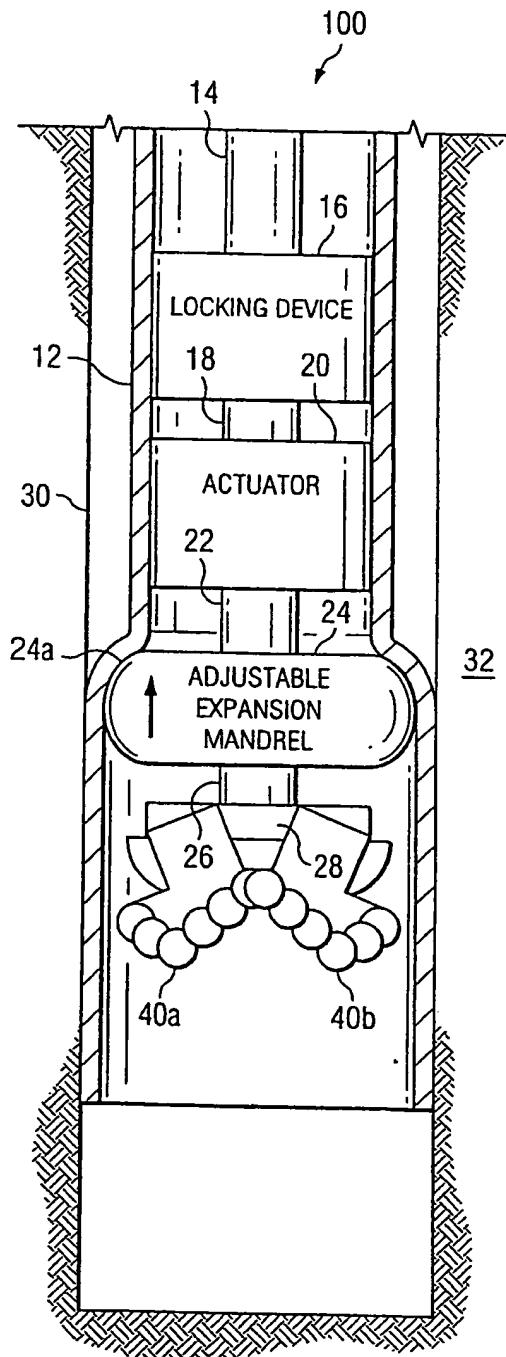


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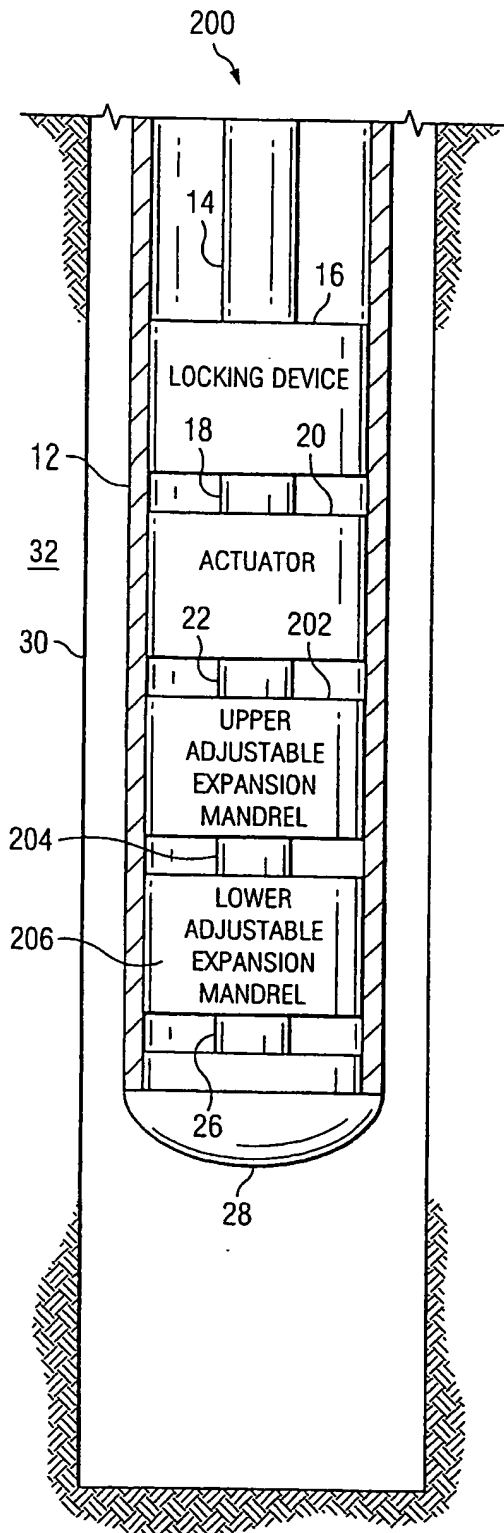


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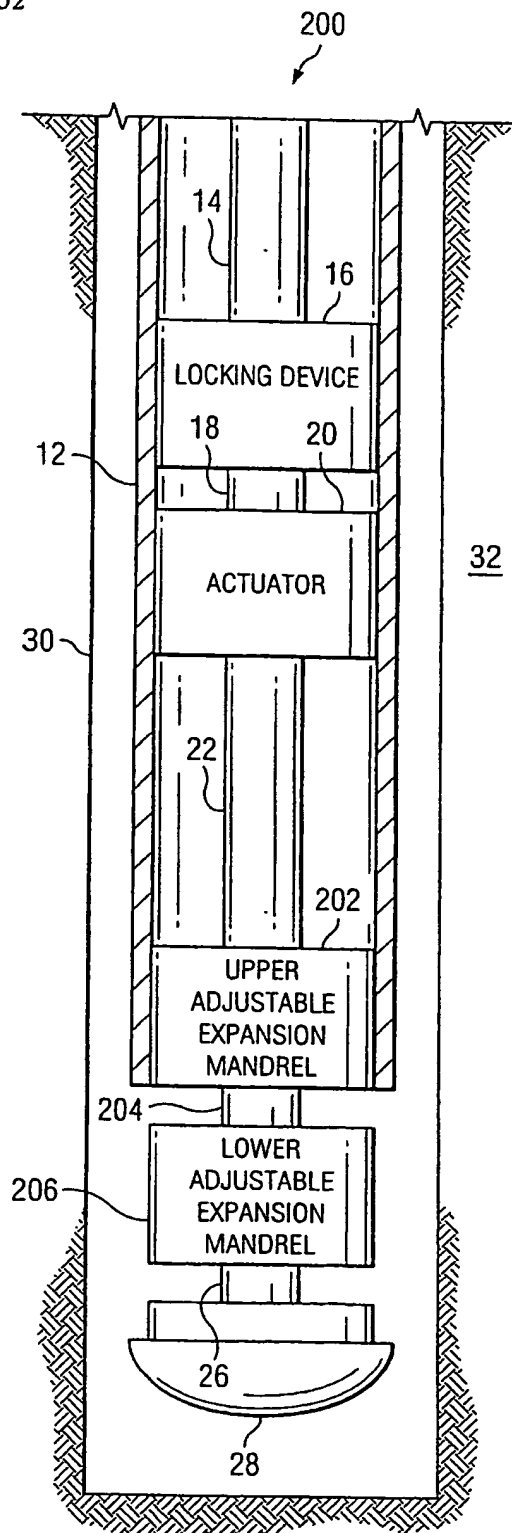


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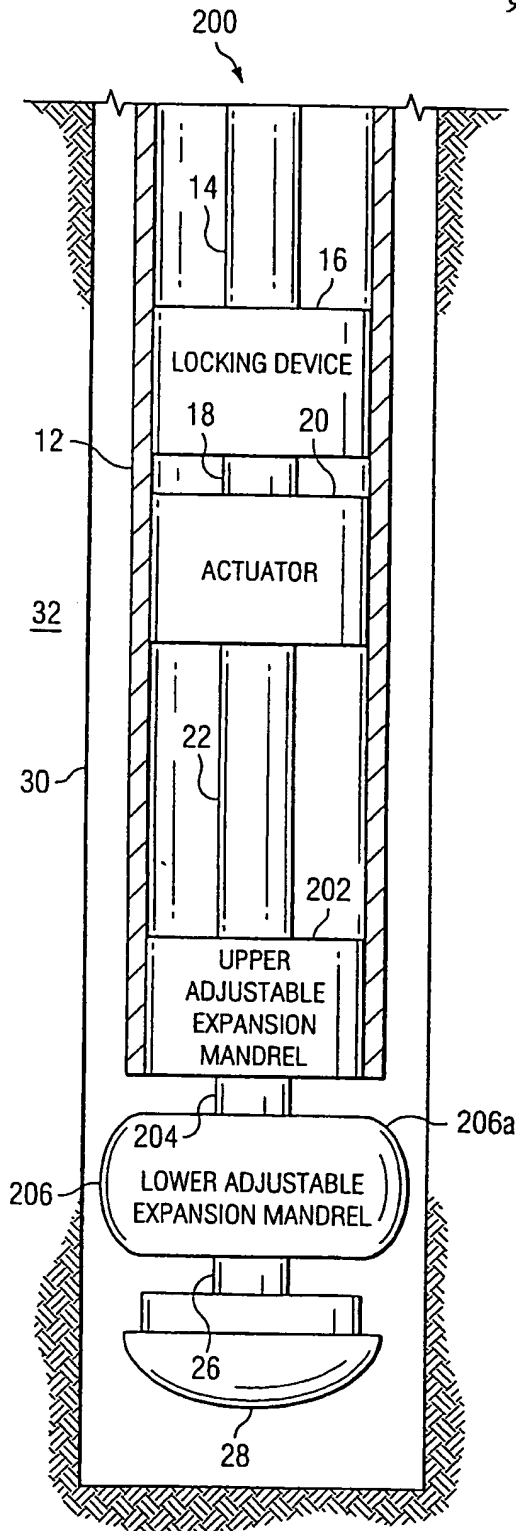


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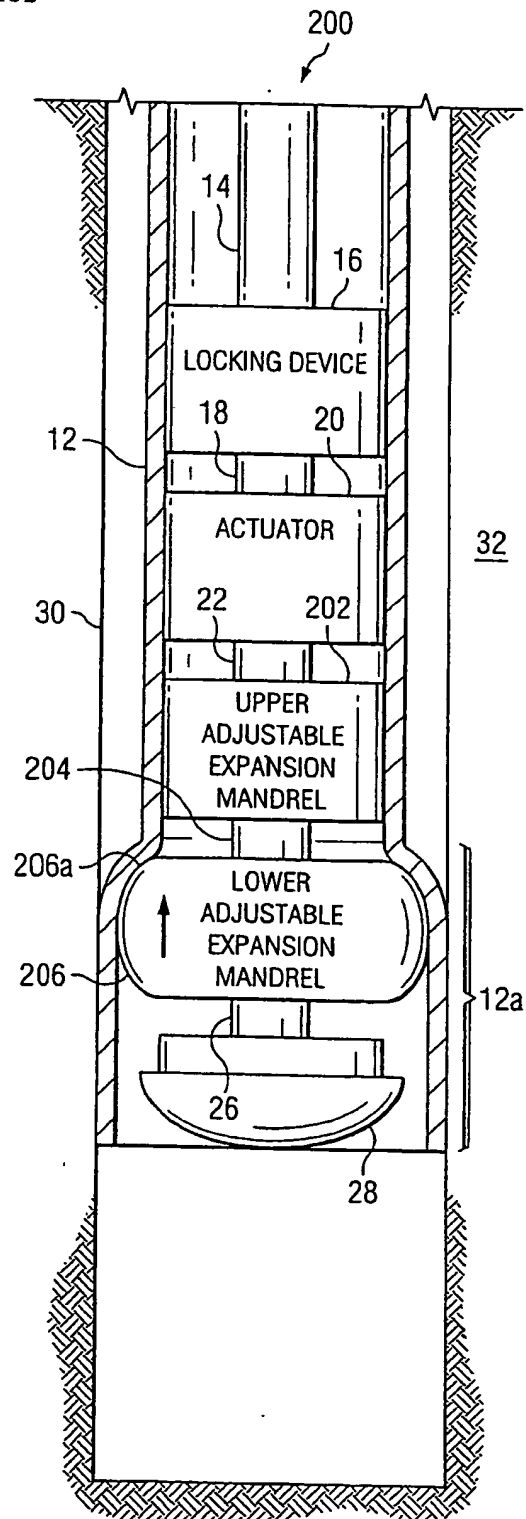


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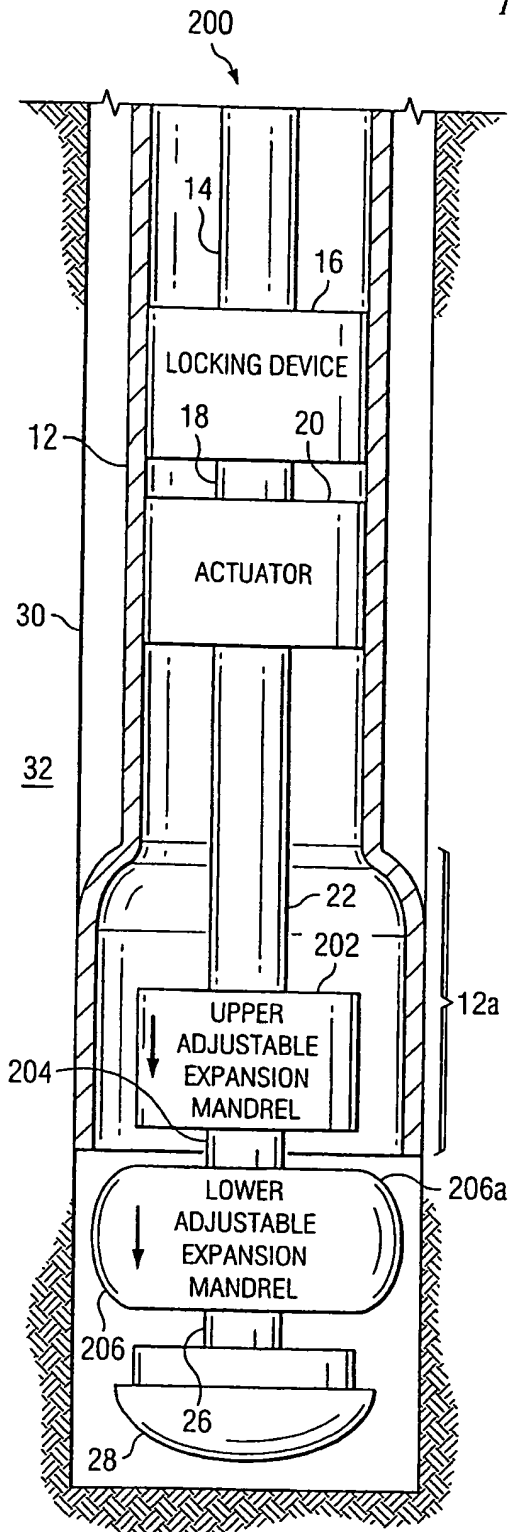


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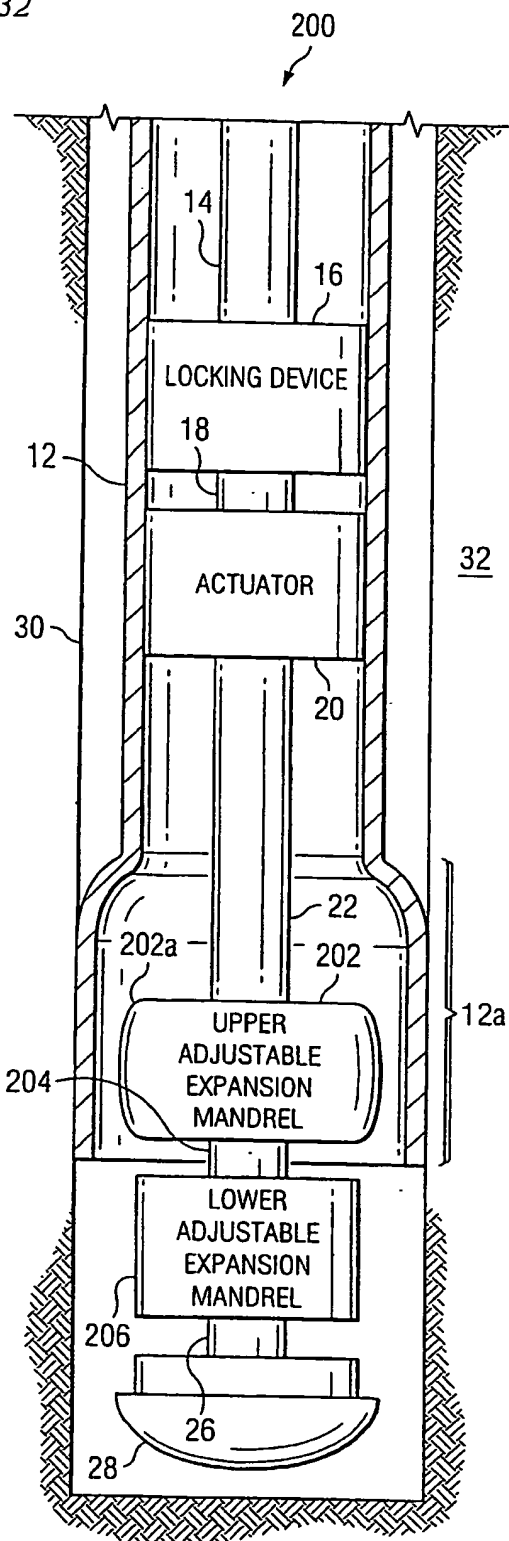


Fig. 19

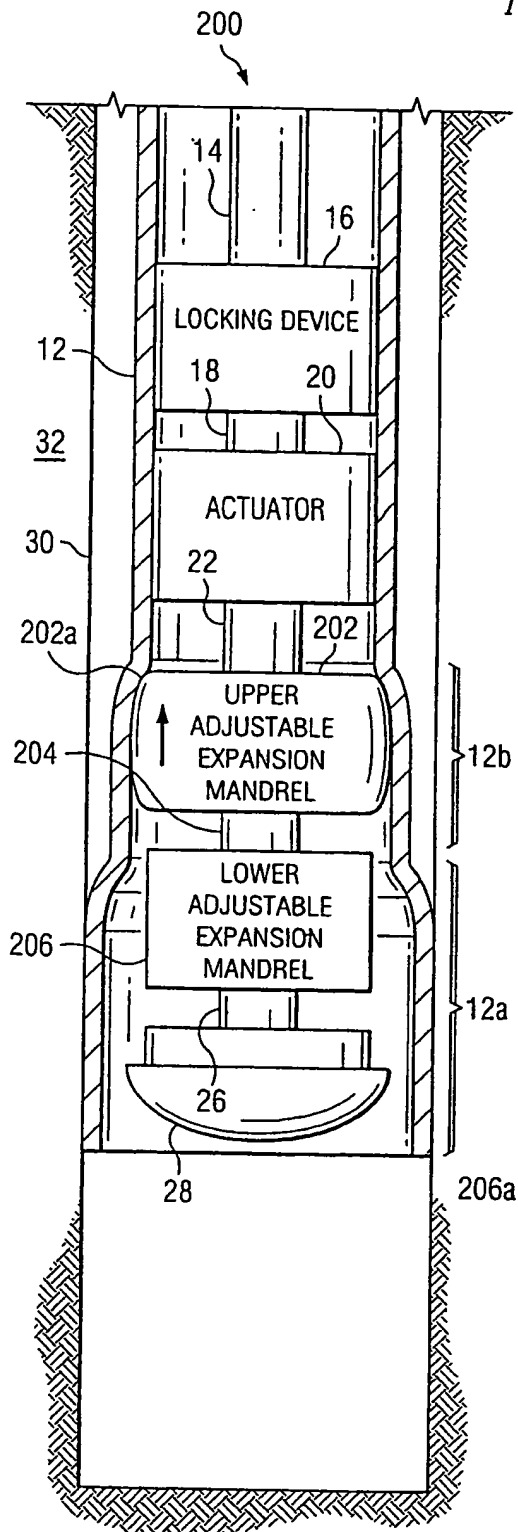


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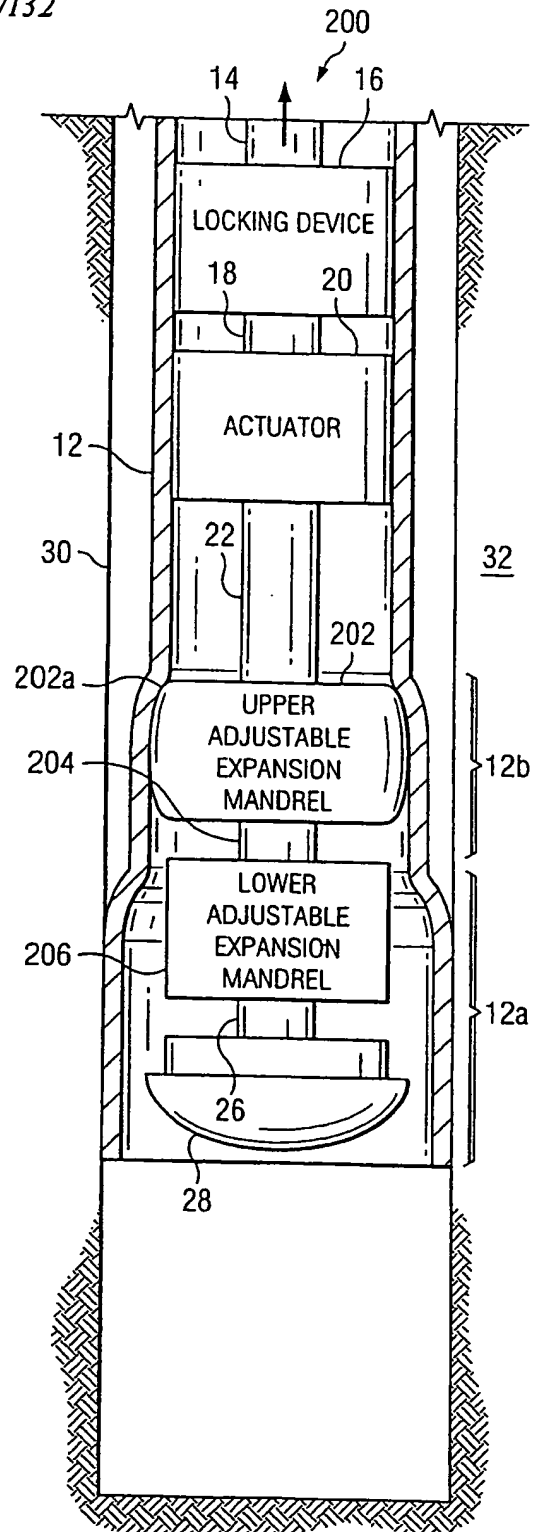


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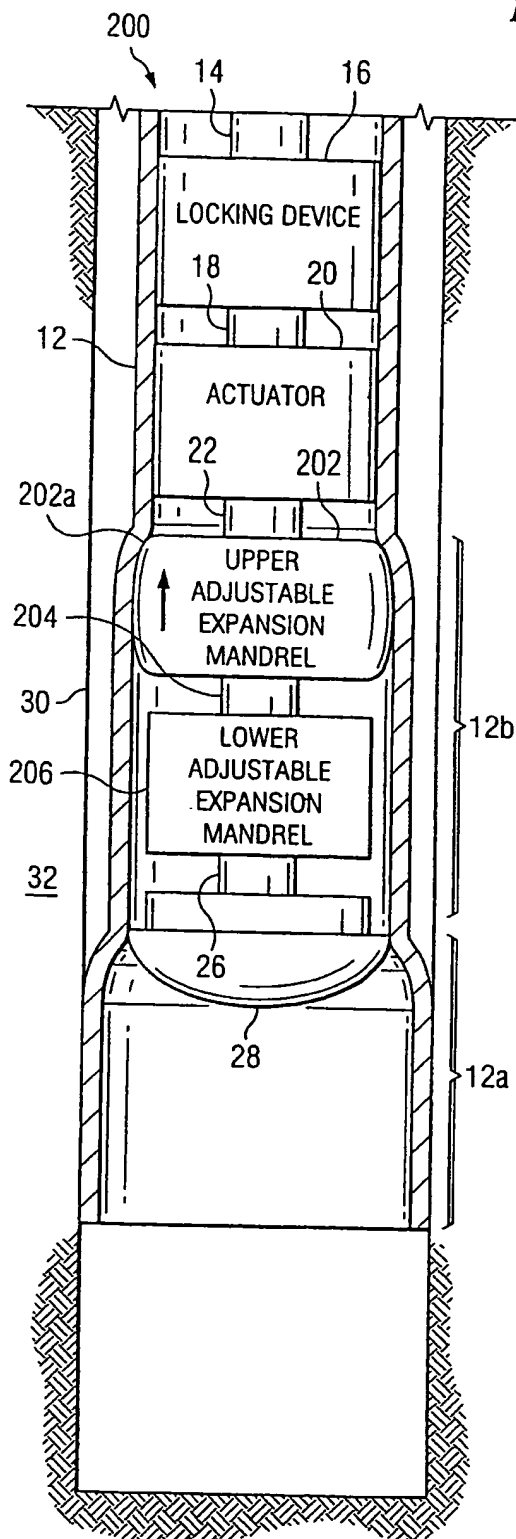


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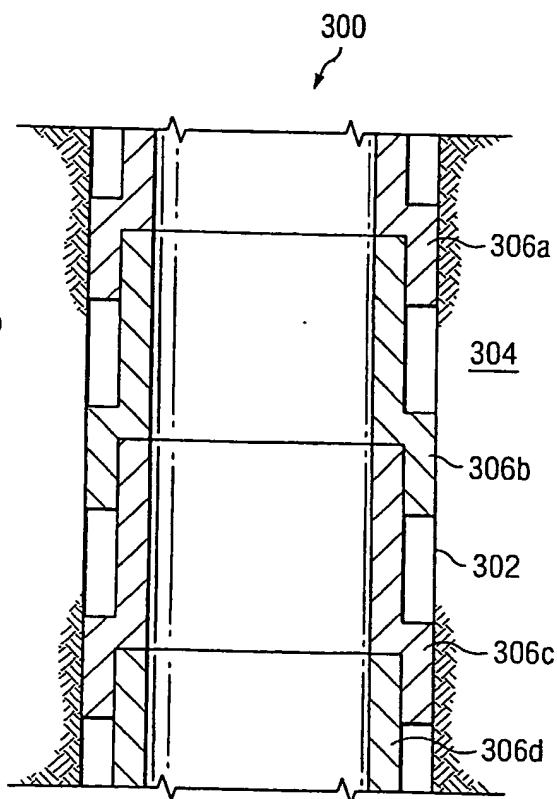


Fig. 23



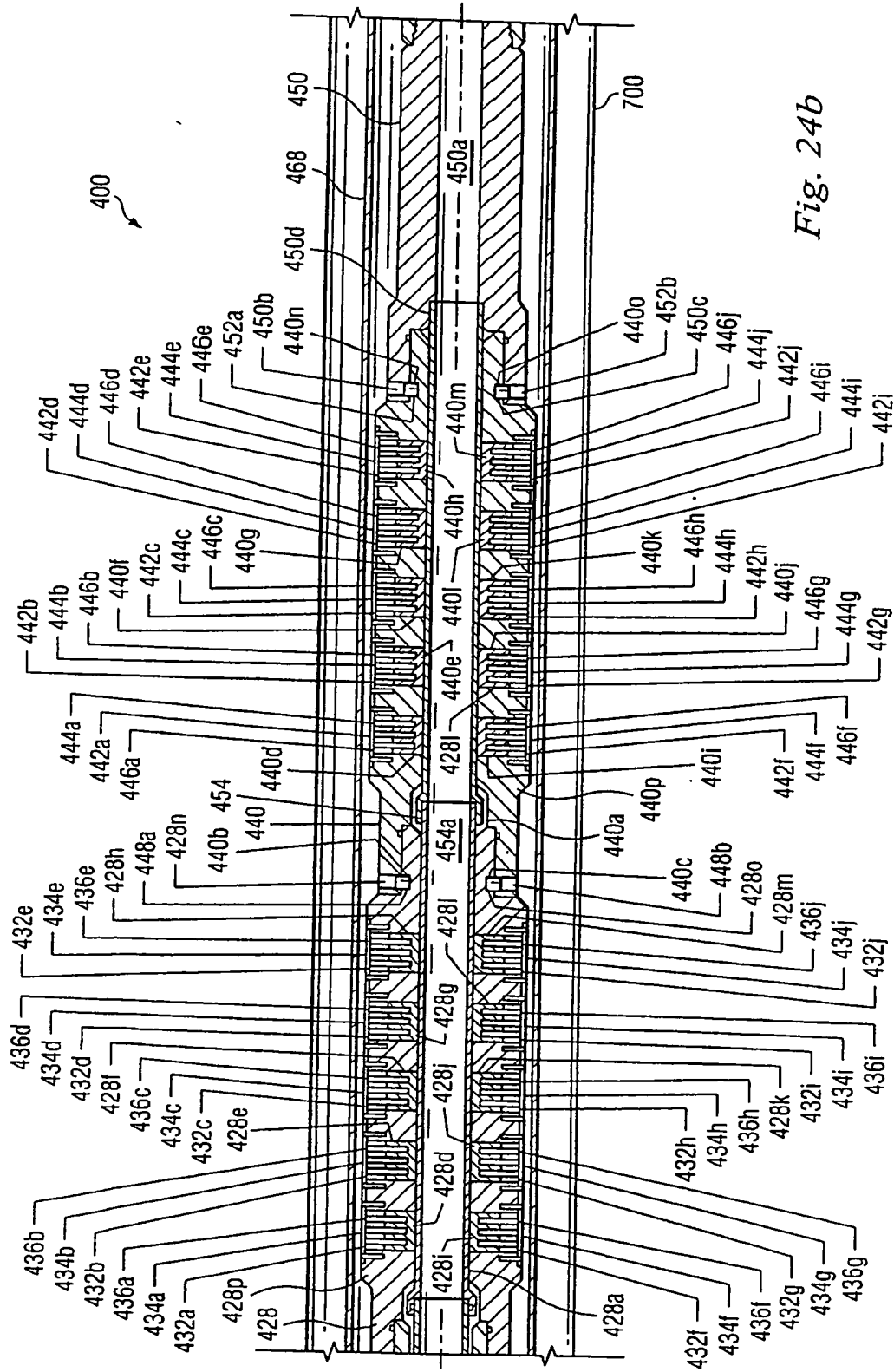


Fig. 24b



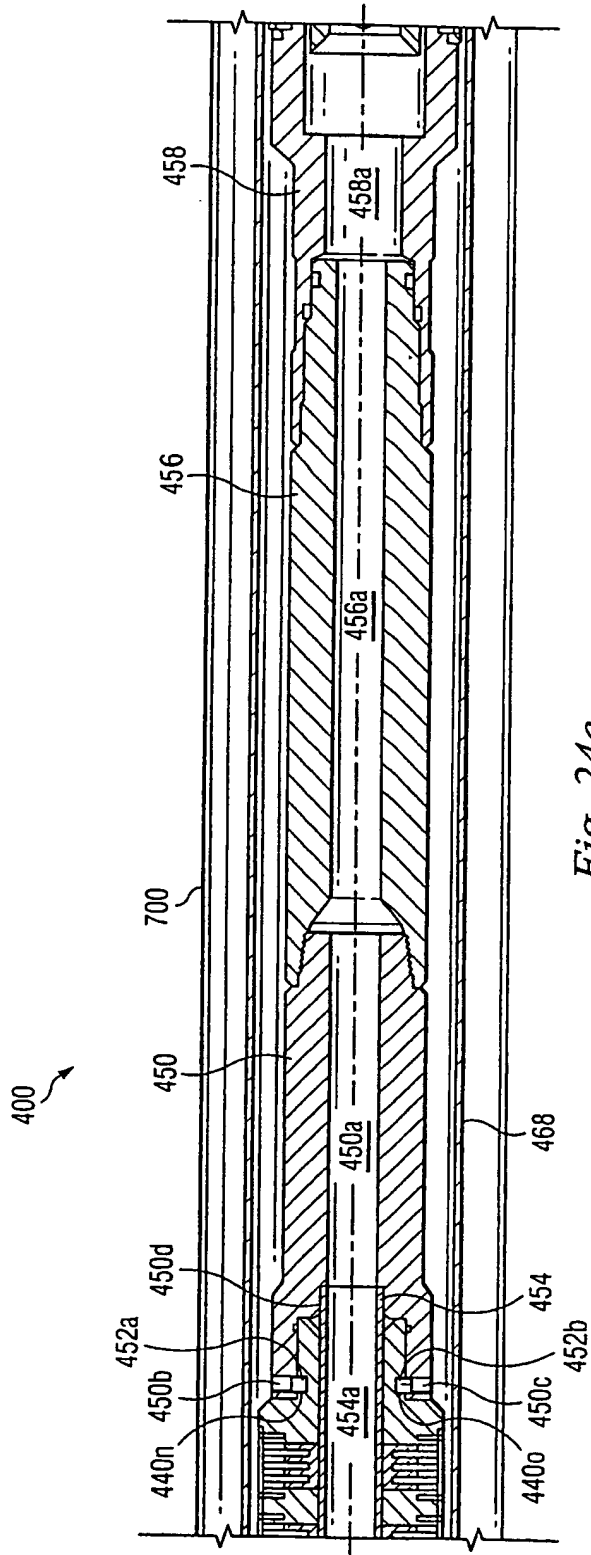


Fig. 24c

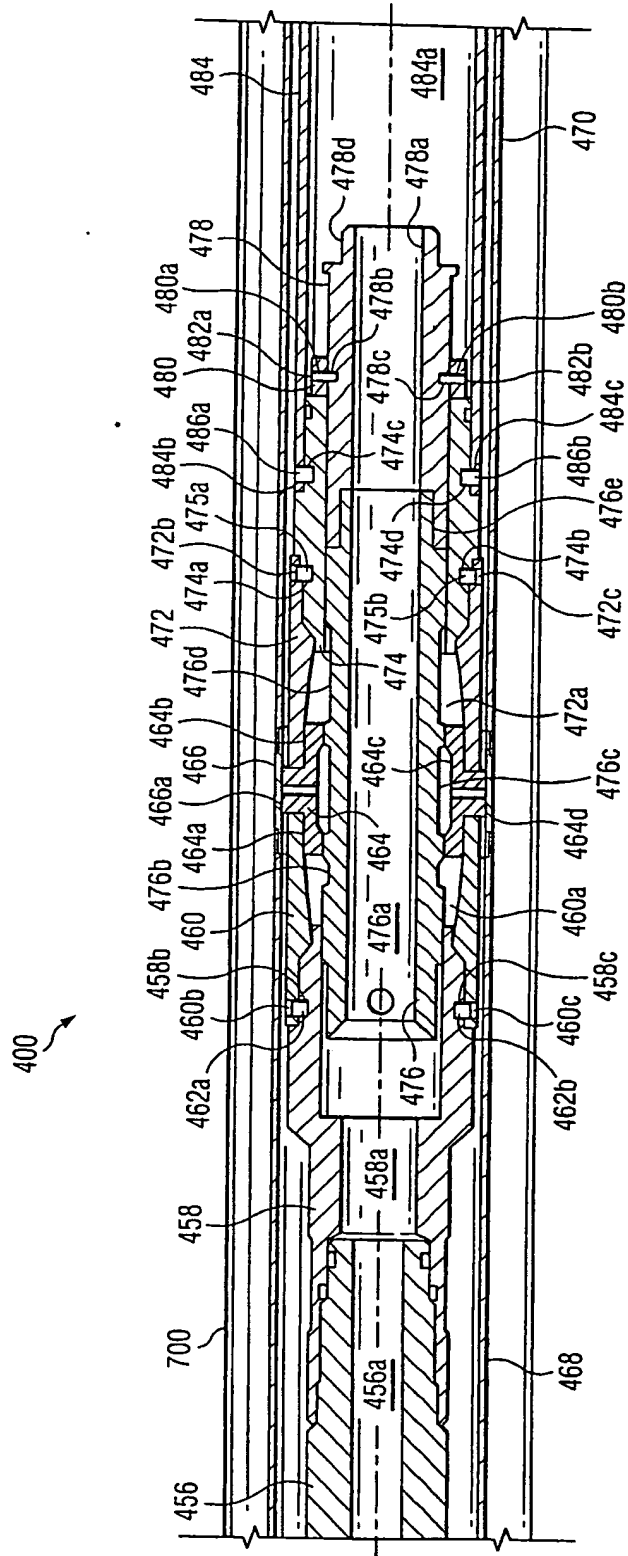


Fig. 24d

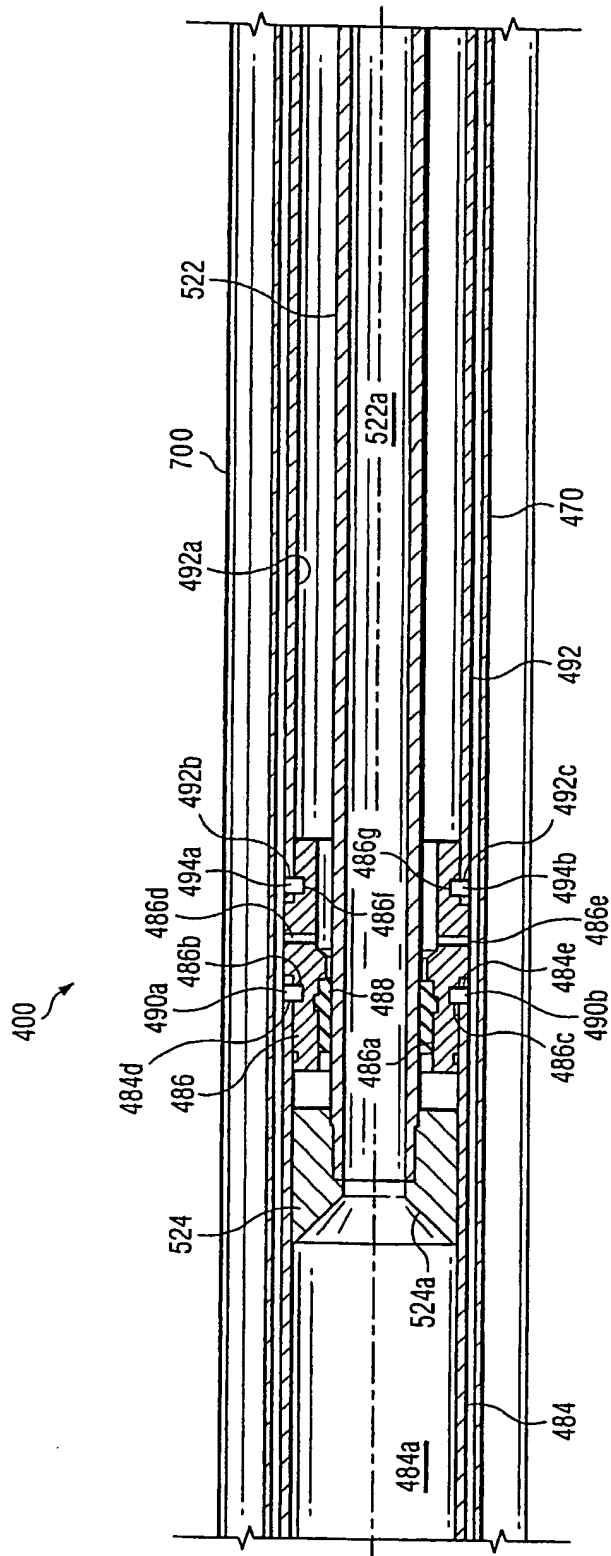


Fig. 24e

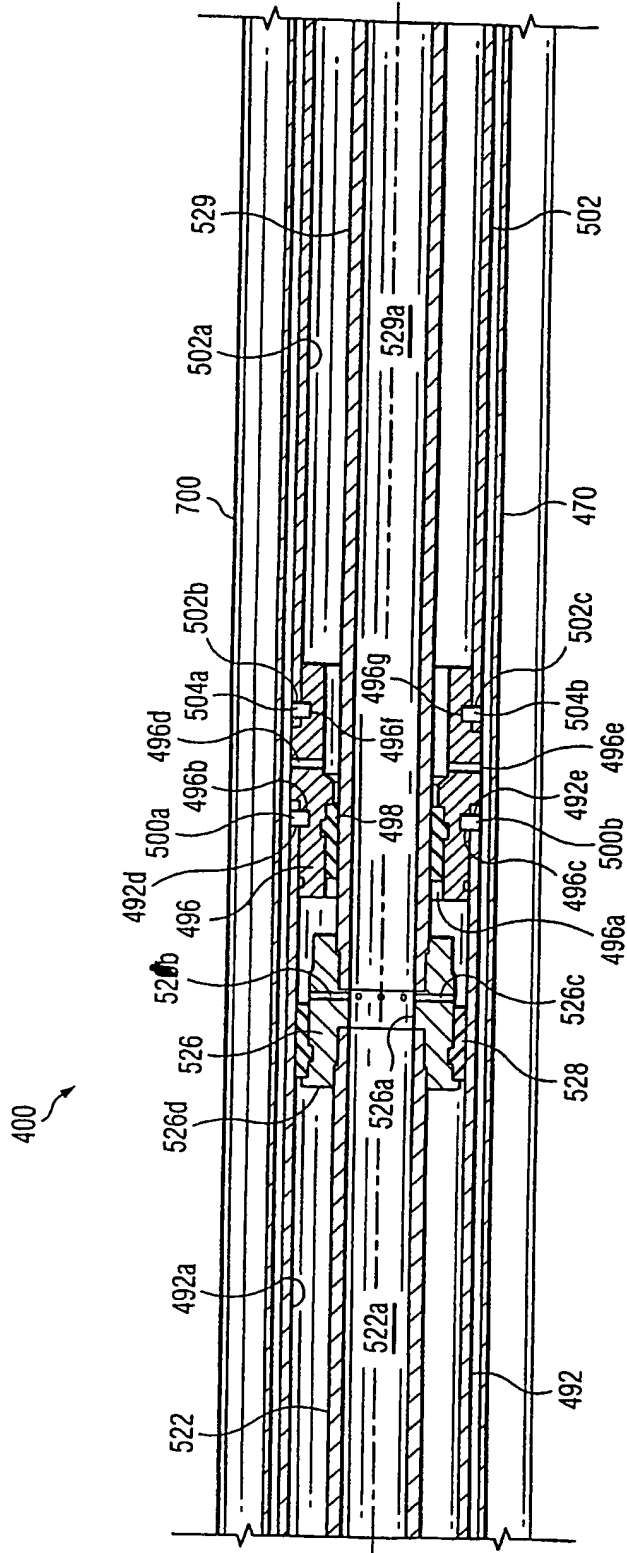


Fig. 24f

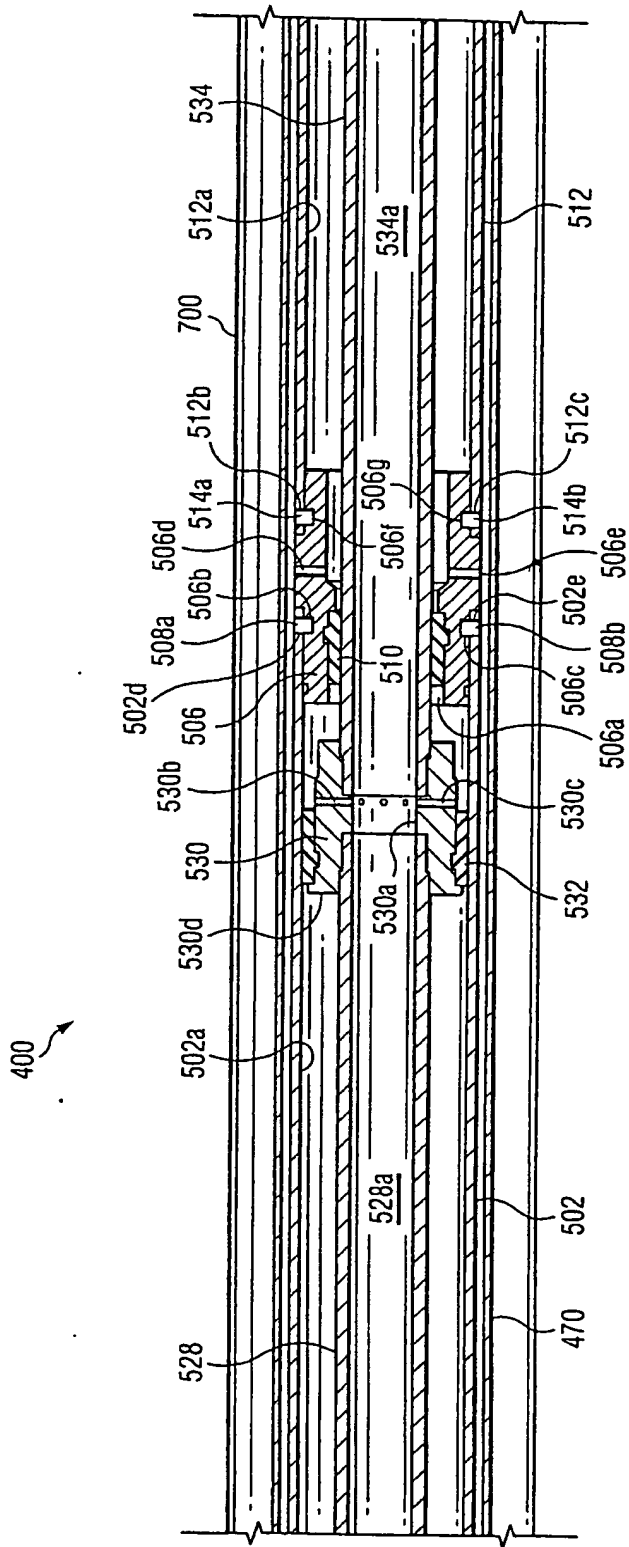


Fig. 24g

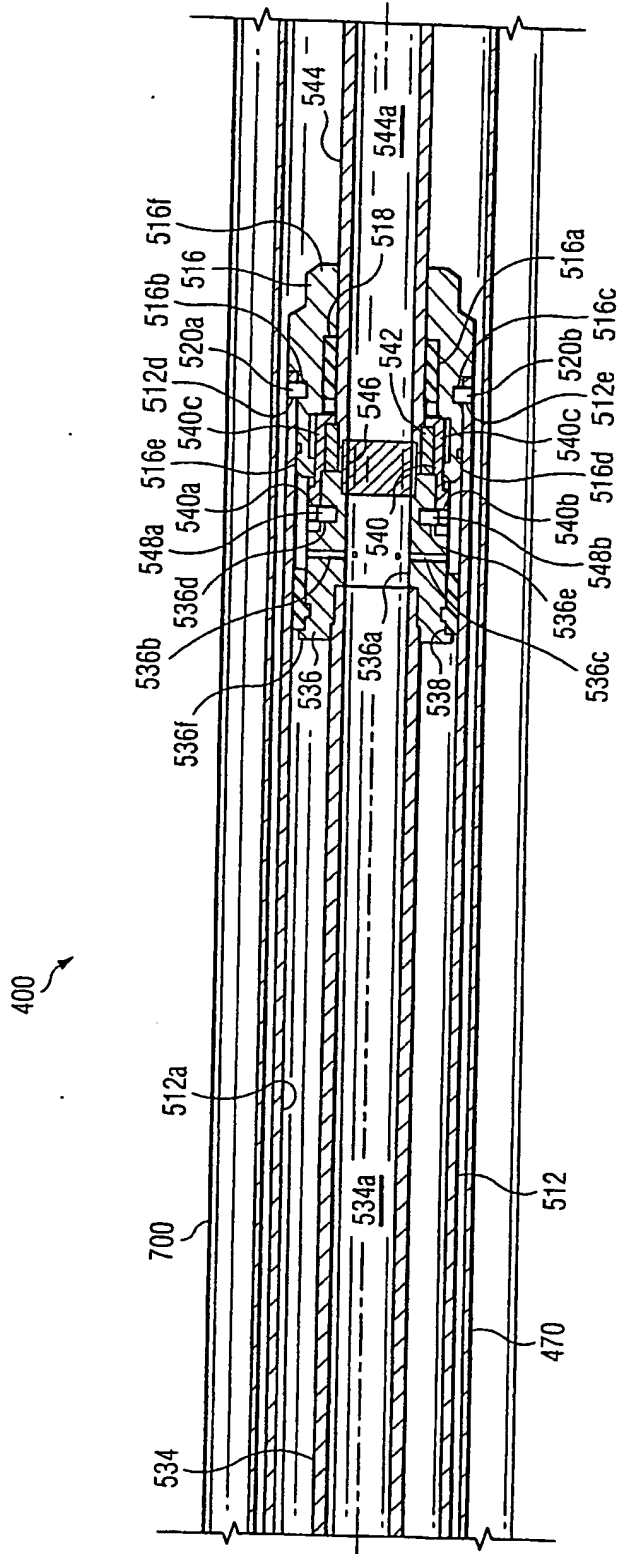


Fig. 24h

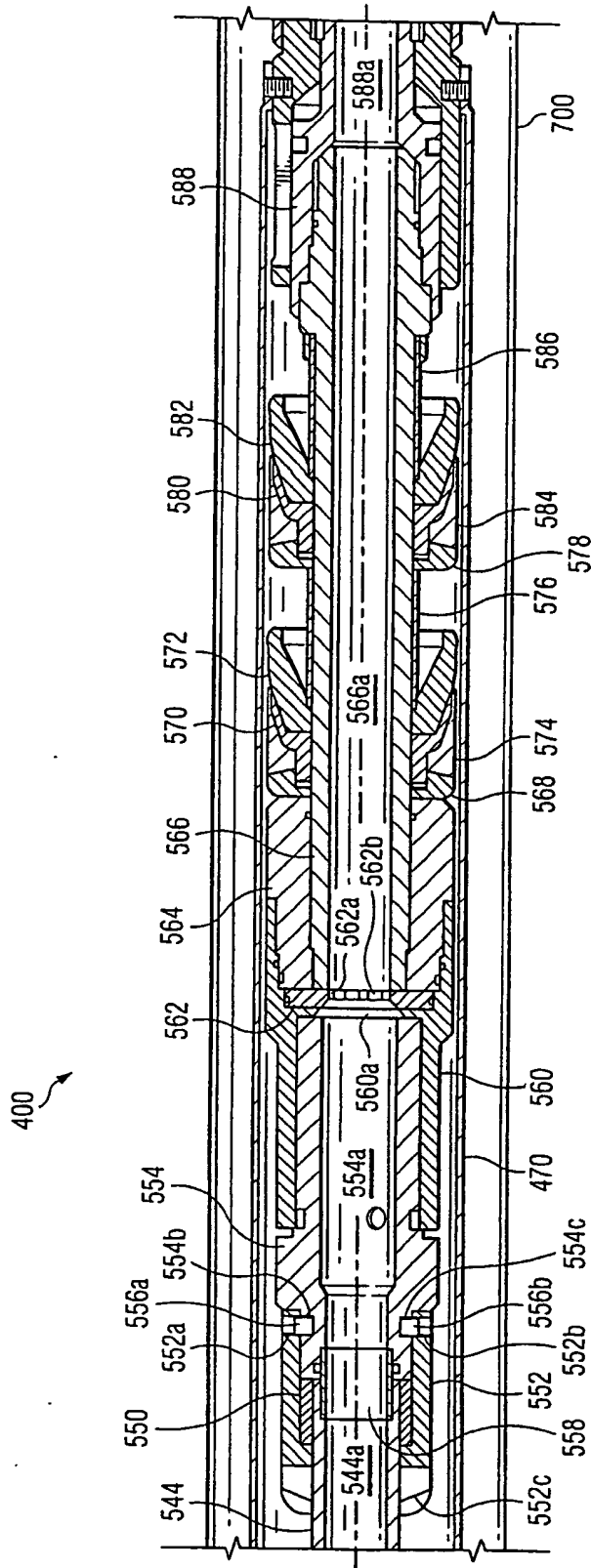


Fig. 24i

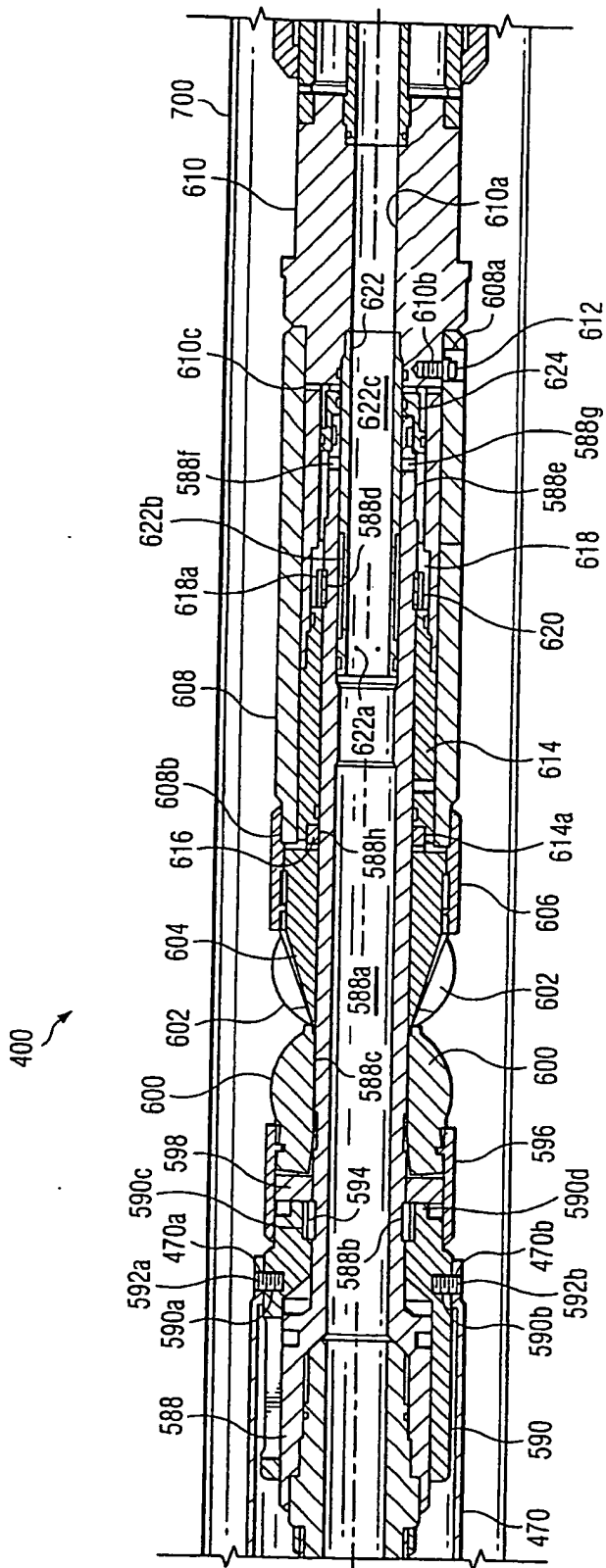


Fig. 24j



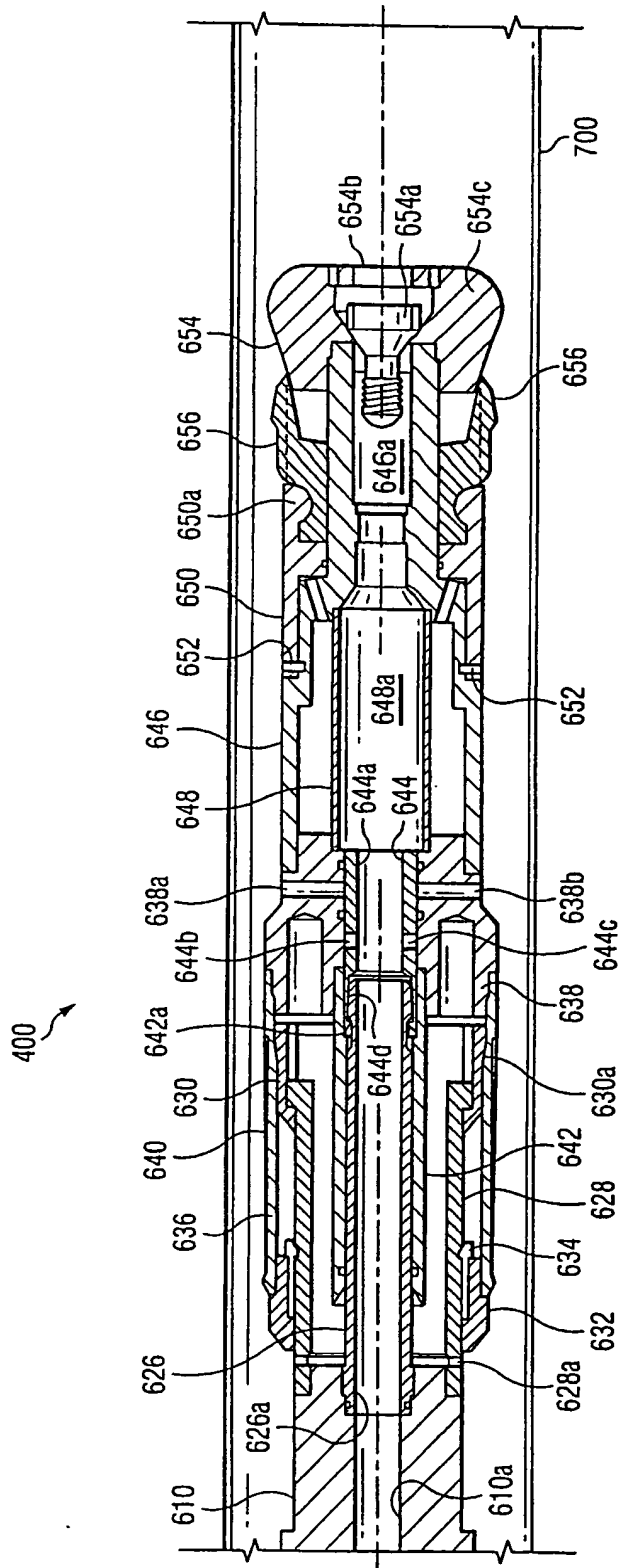


Fig. 24k

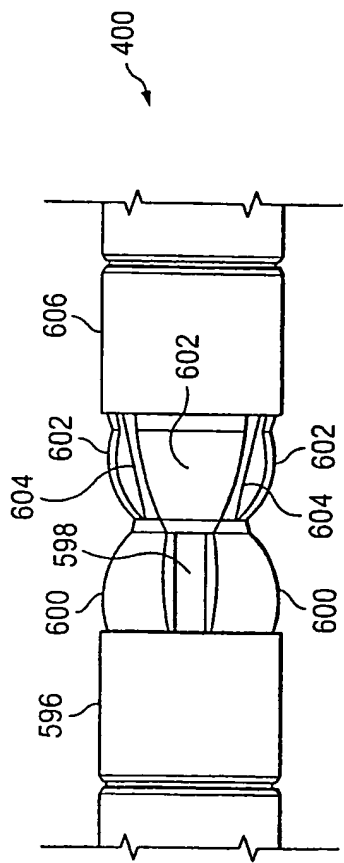


Fig. 25a

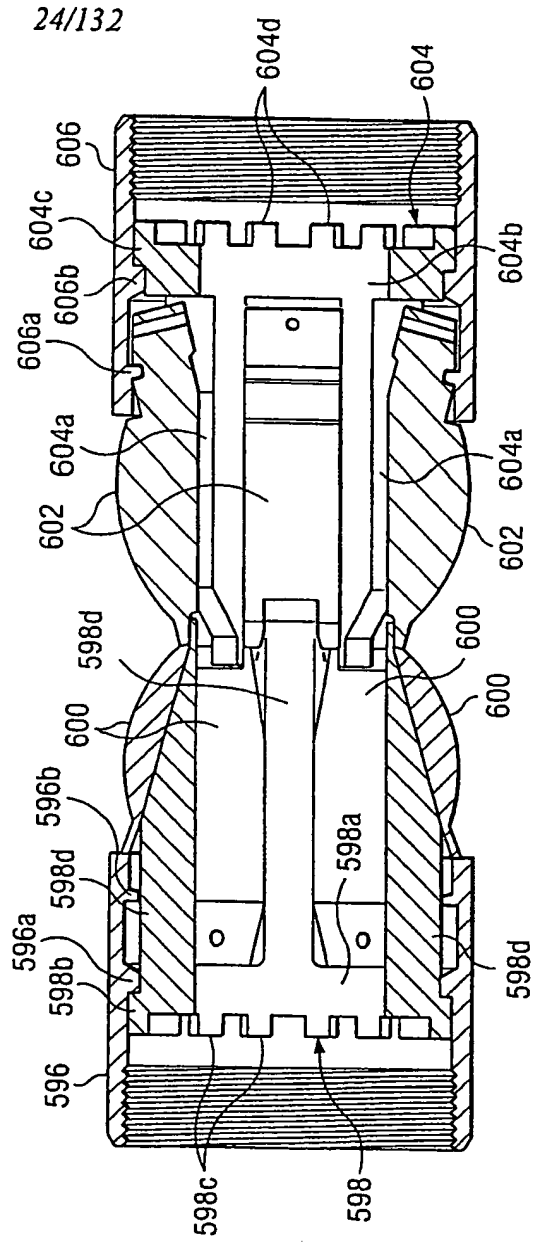


FIG. 25b

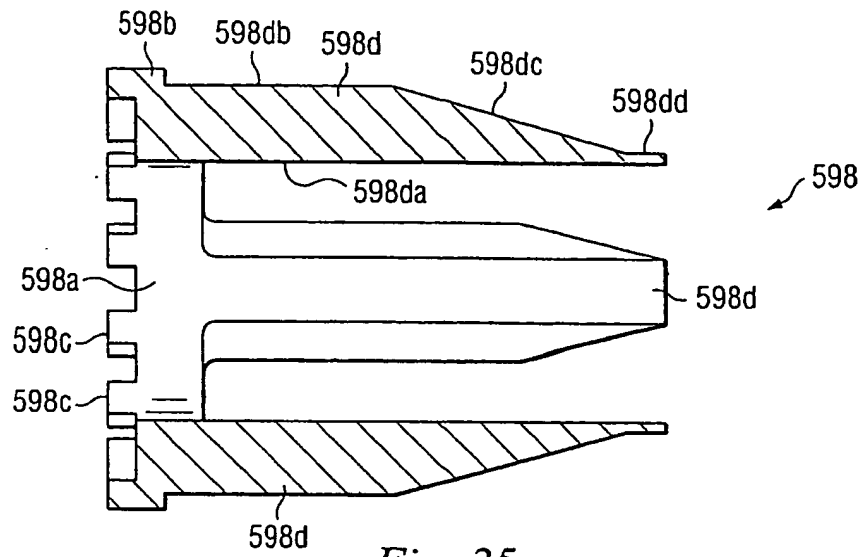


Fig. 25c

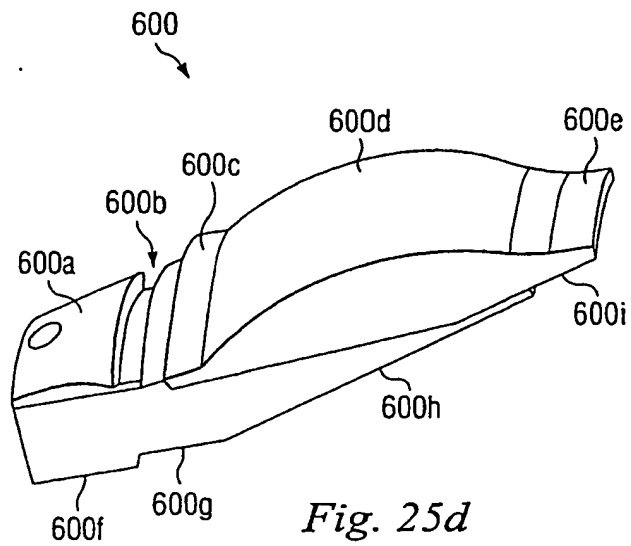
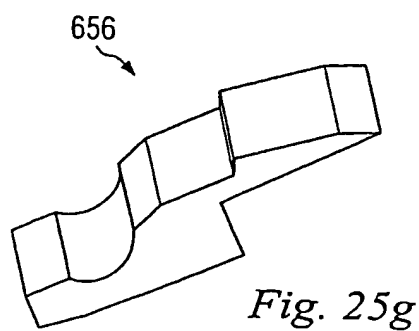
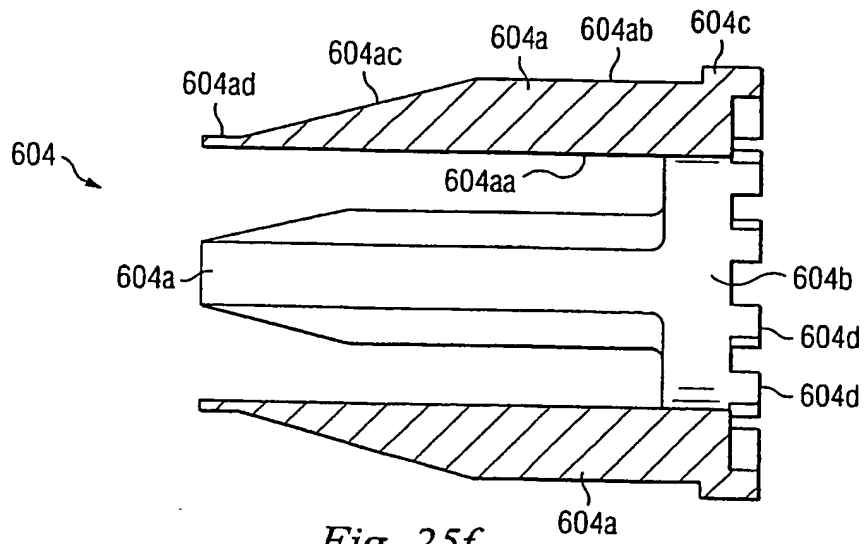
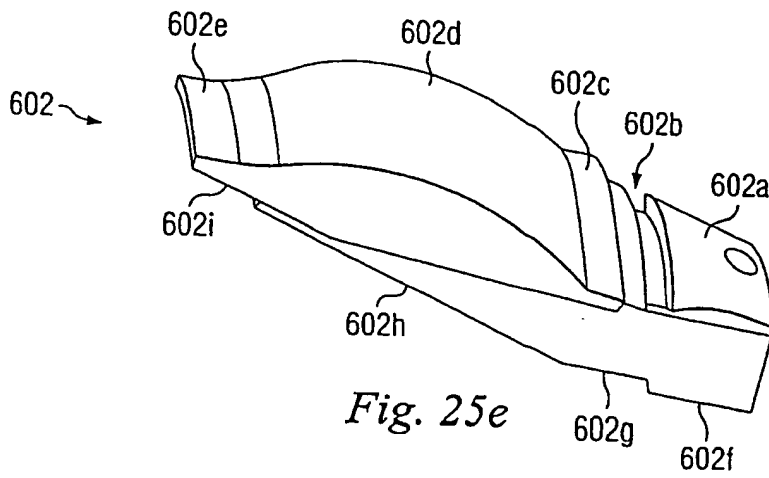


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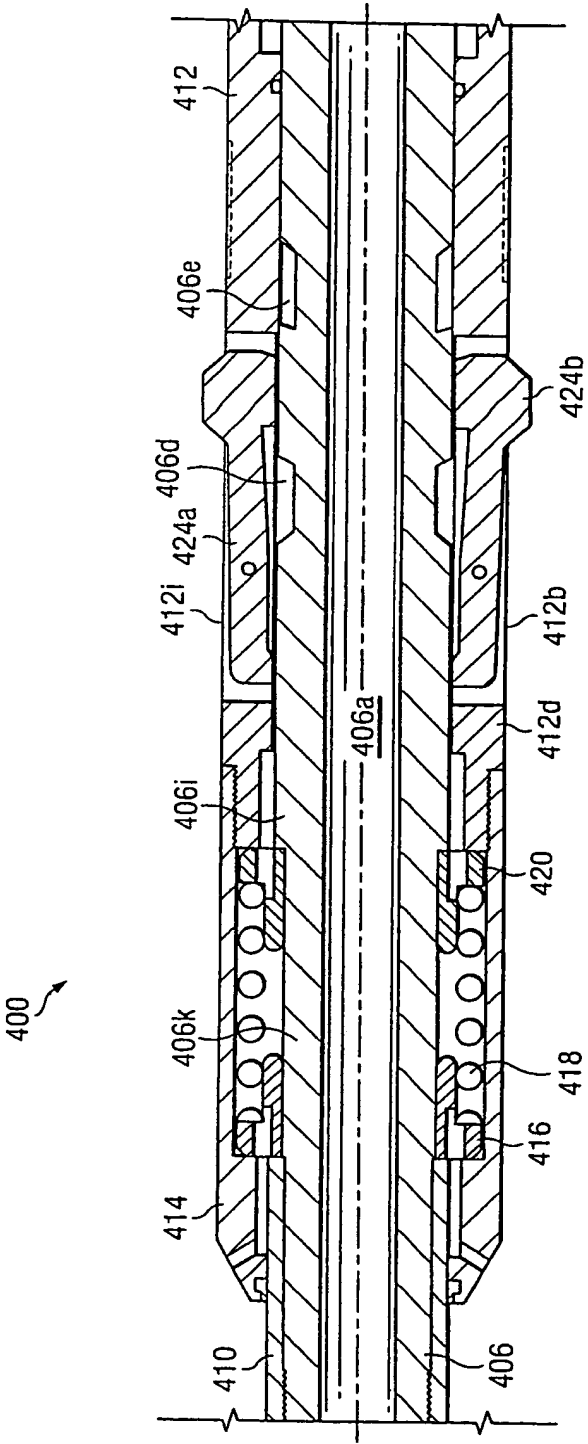


Fig. 25h



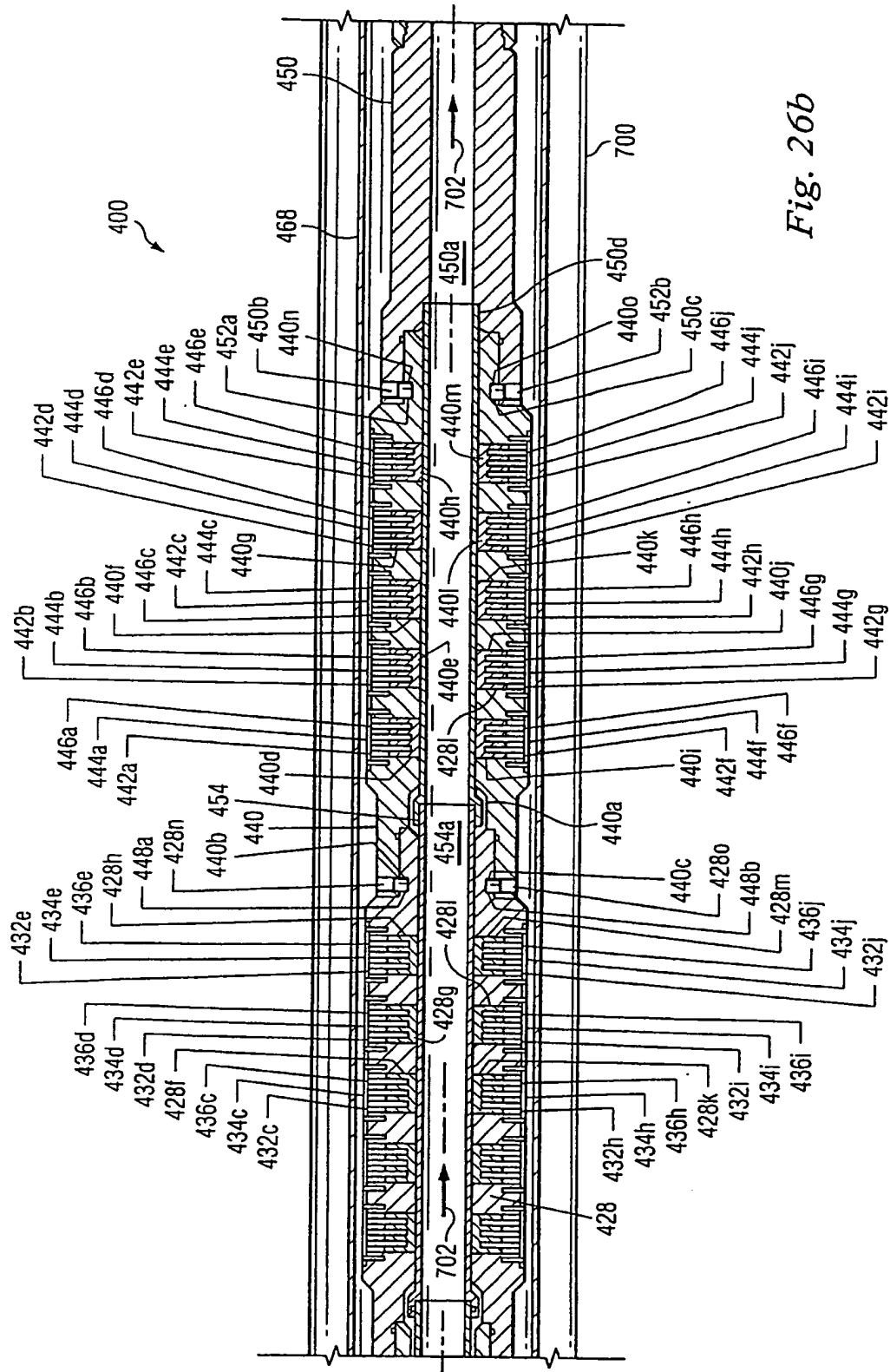


Fig. 26b

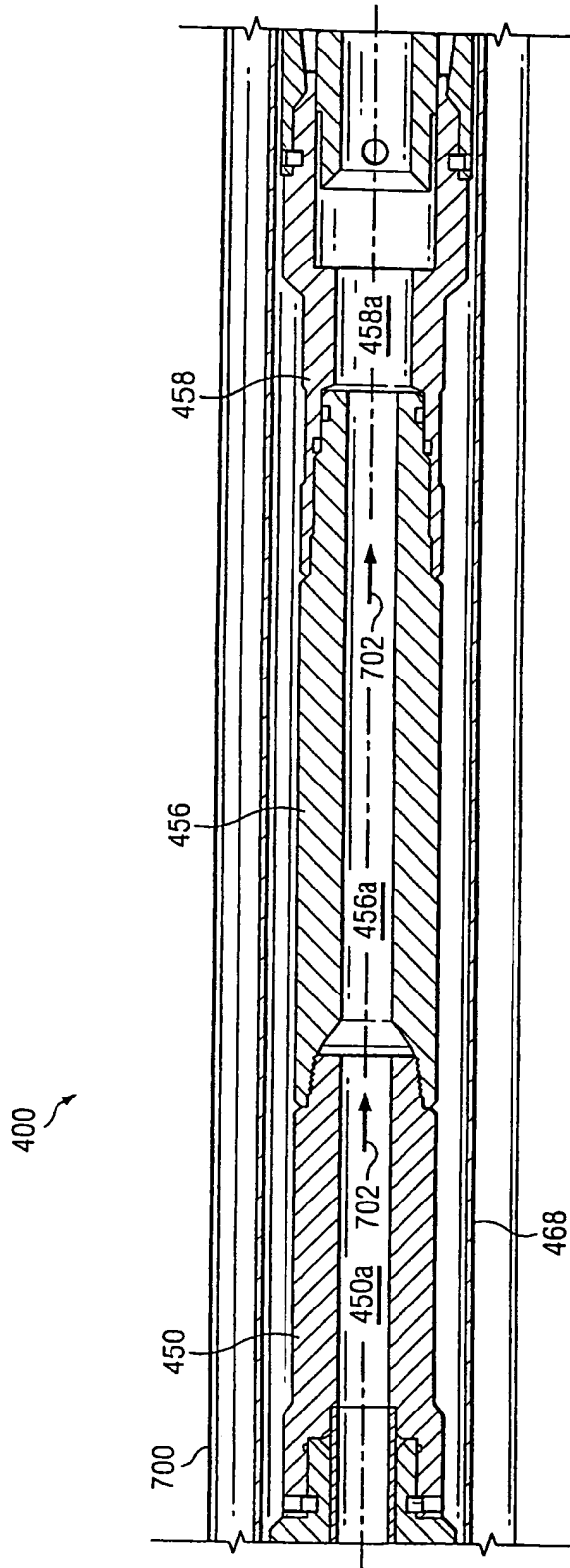


Fig. 26c



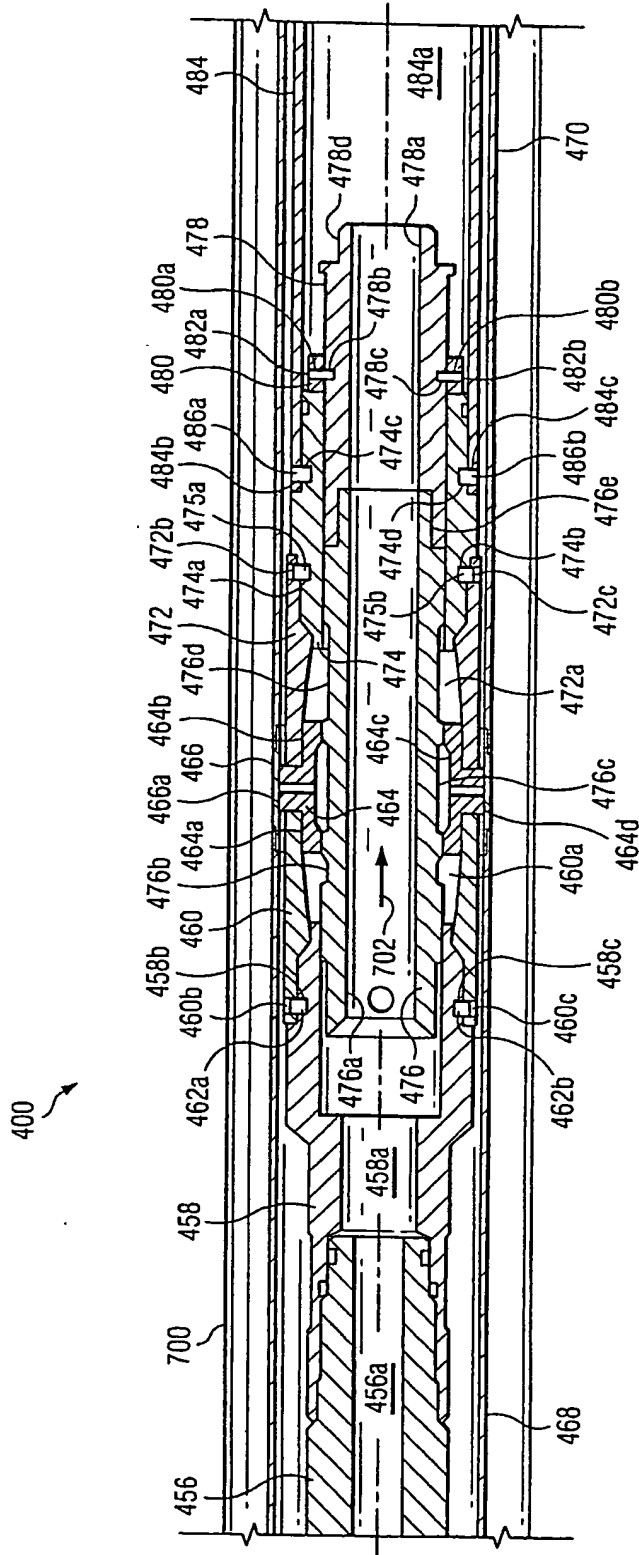


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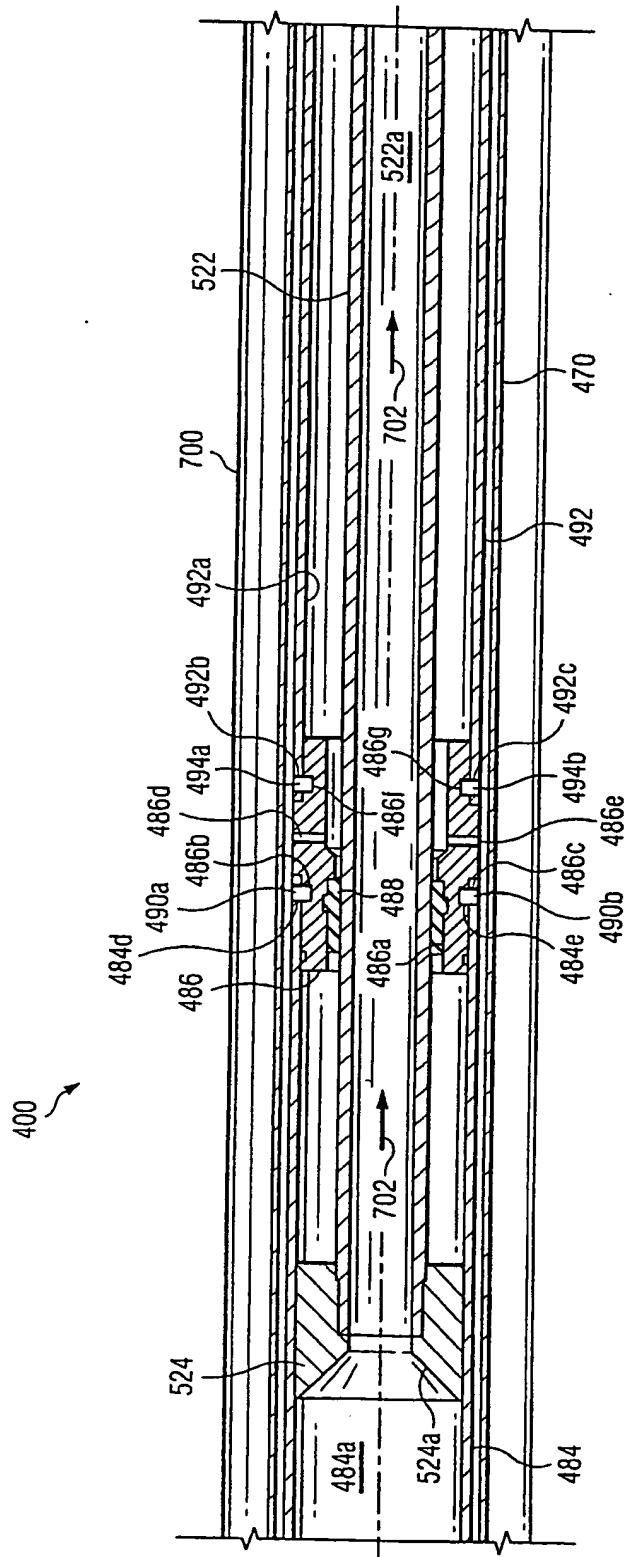


Fig. 26e

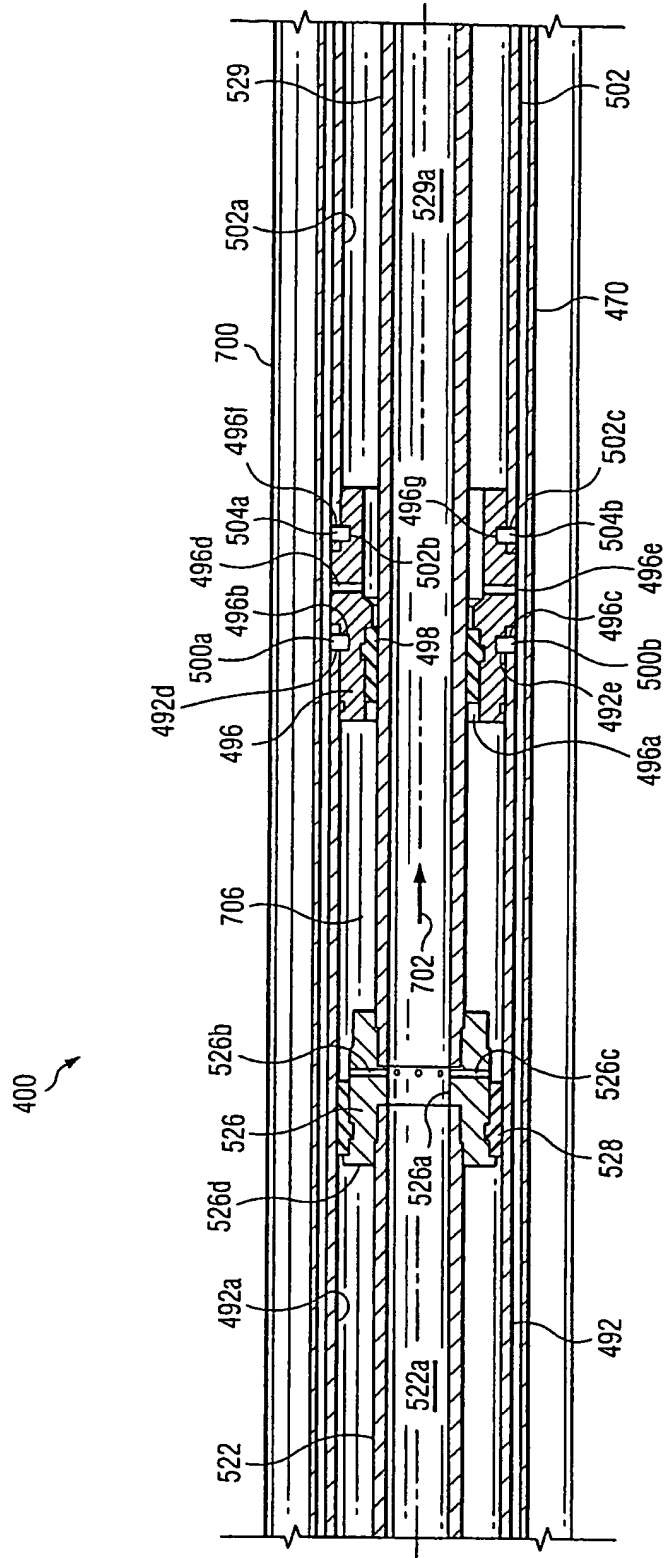


Fig. 26f

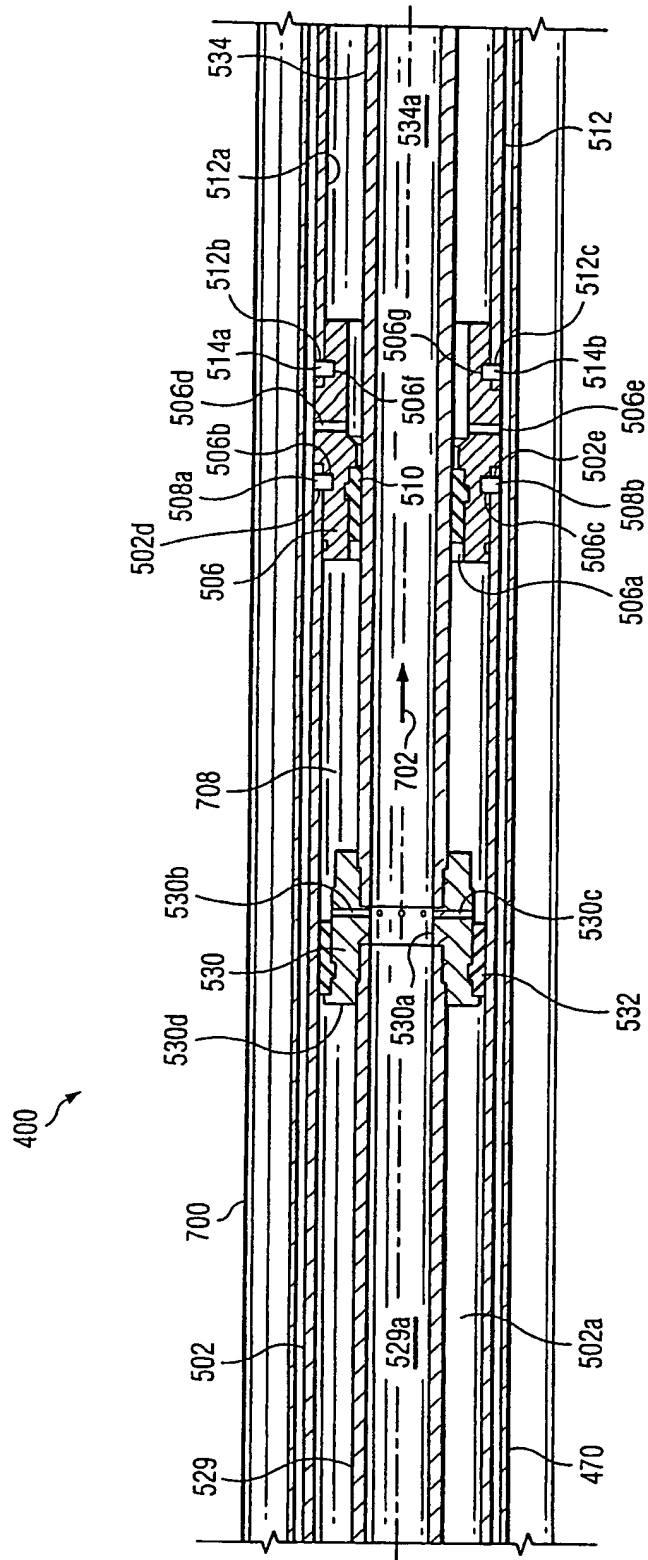


Fig. 26g

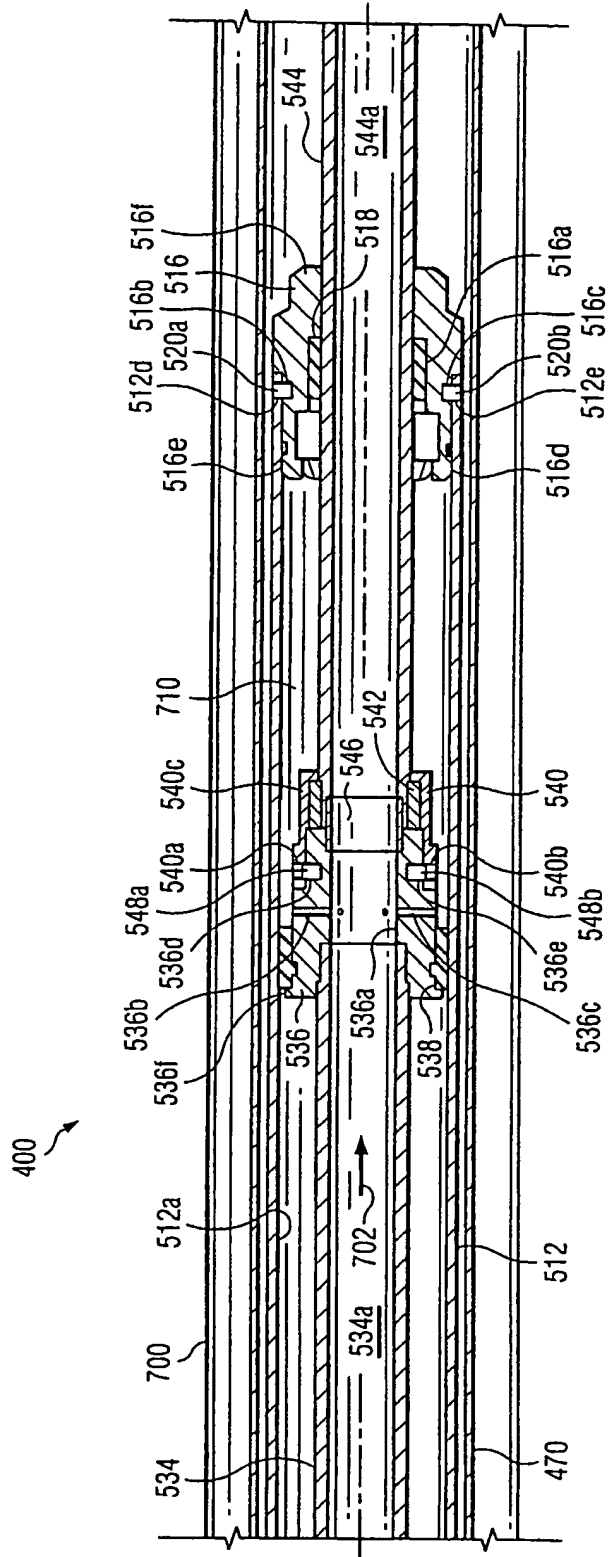


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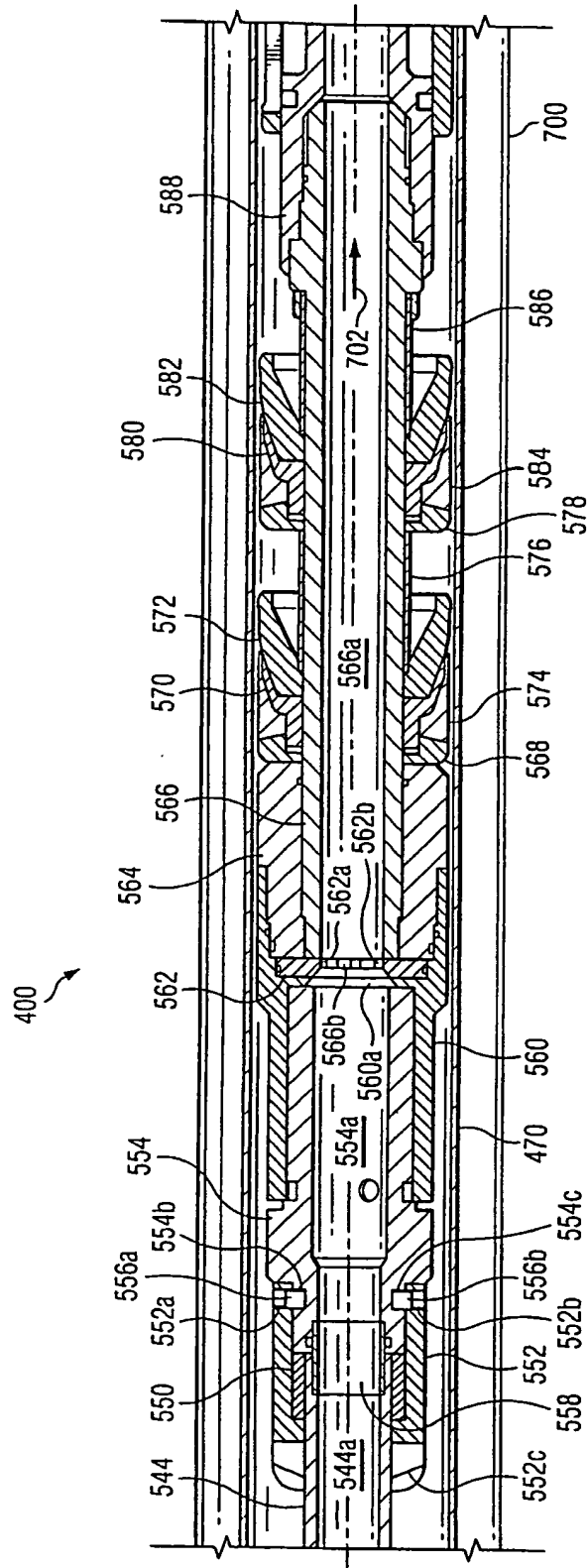


Fig. 26i

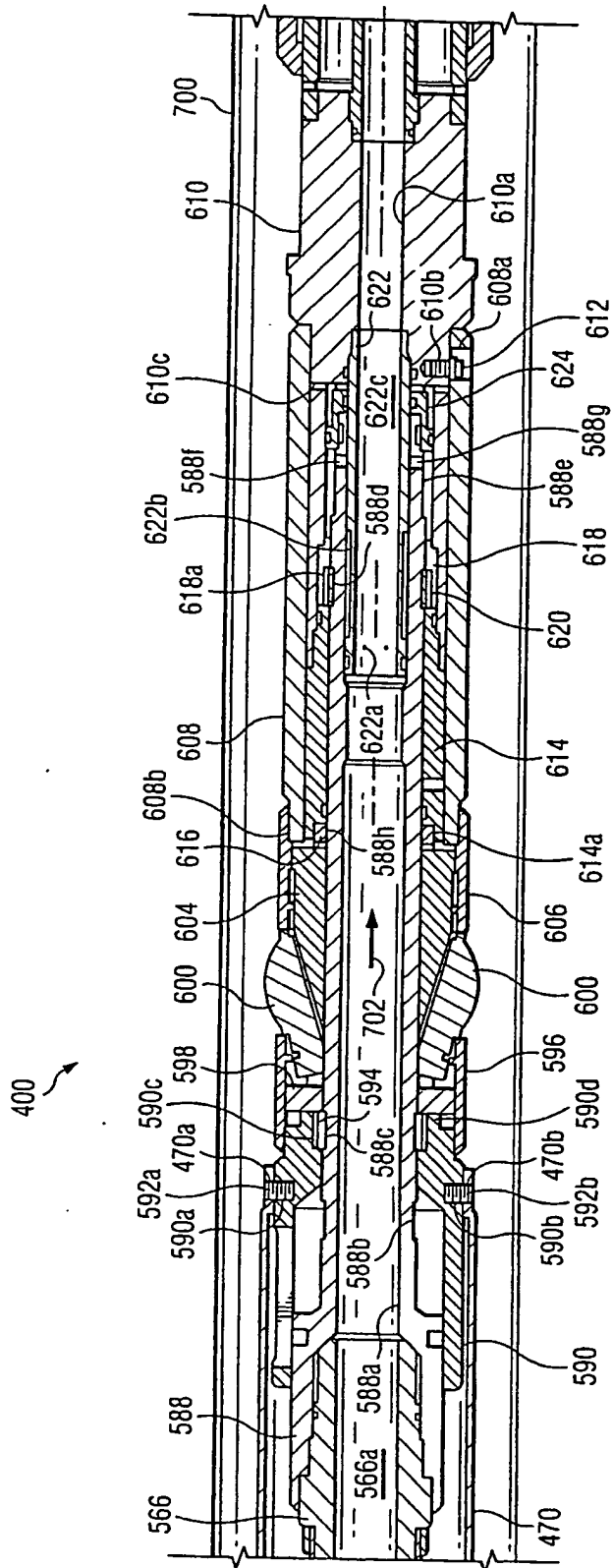


Fig. 26j

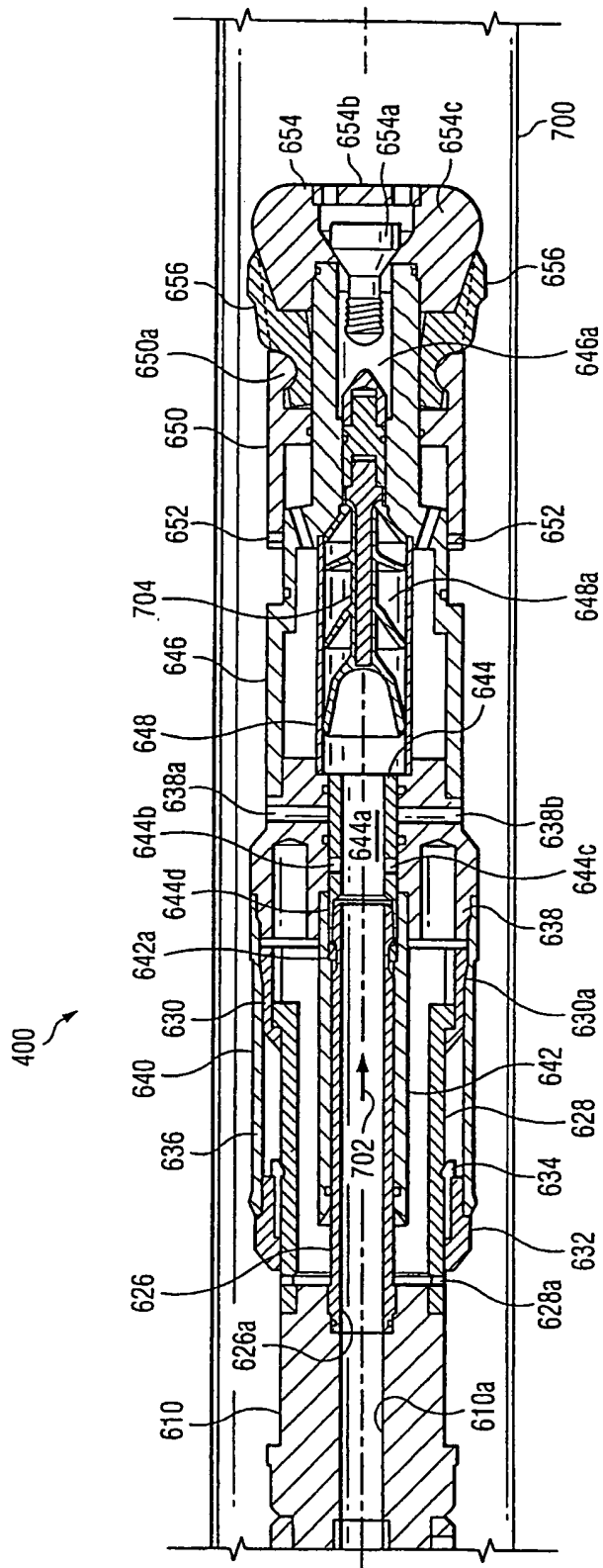


Fig. 26k



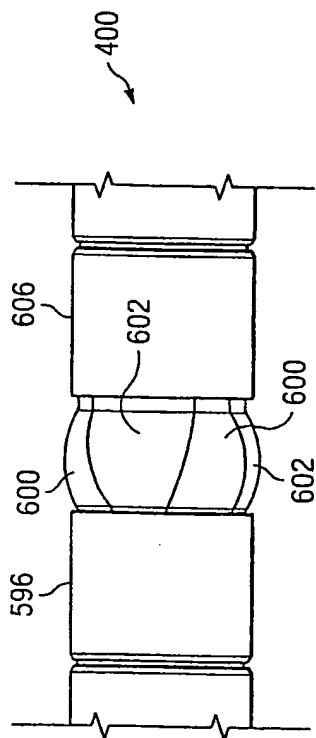


Fig. 27a

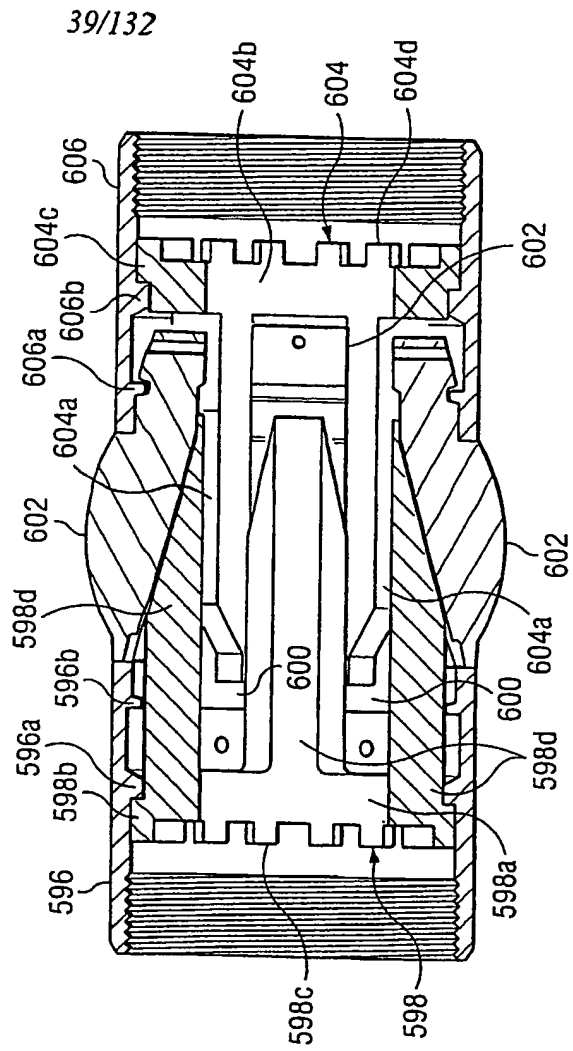
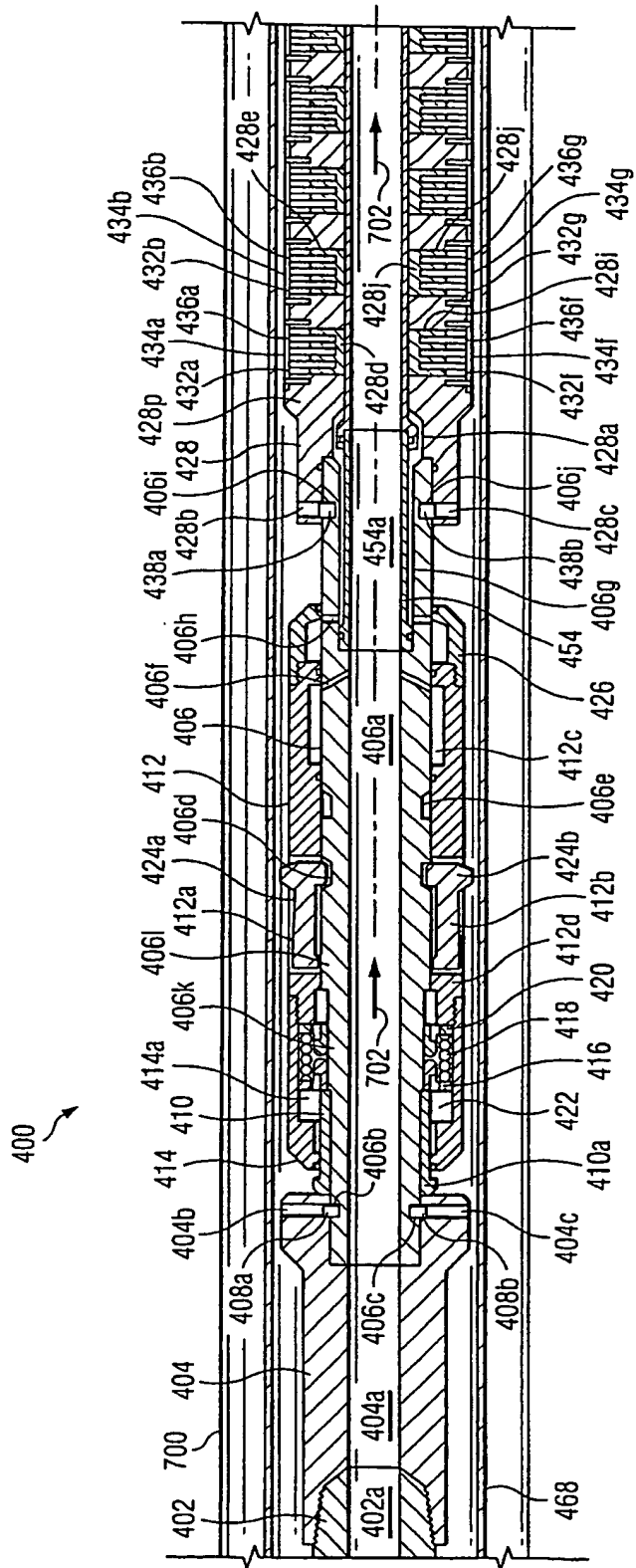


Fig. 27b



*Fig. 28a*

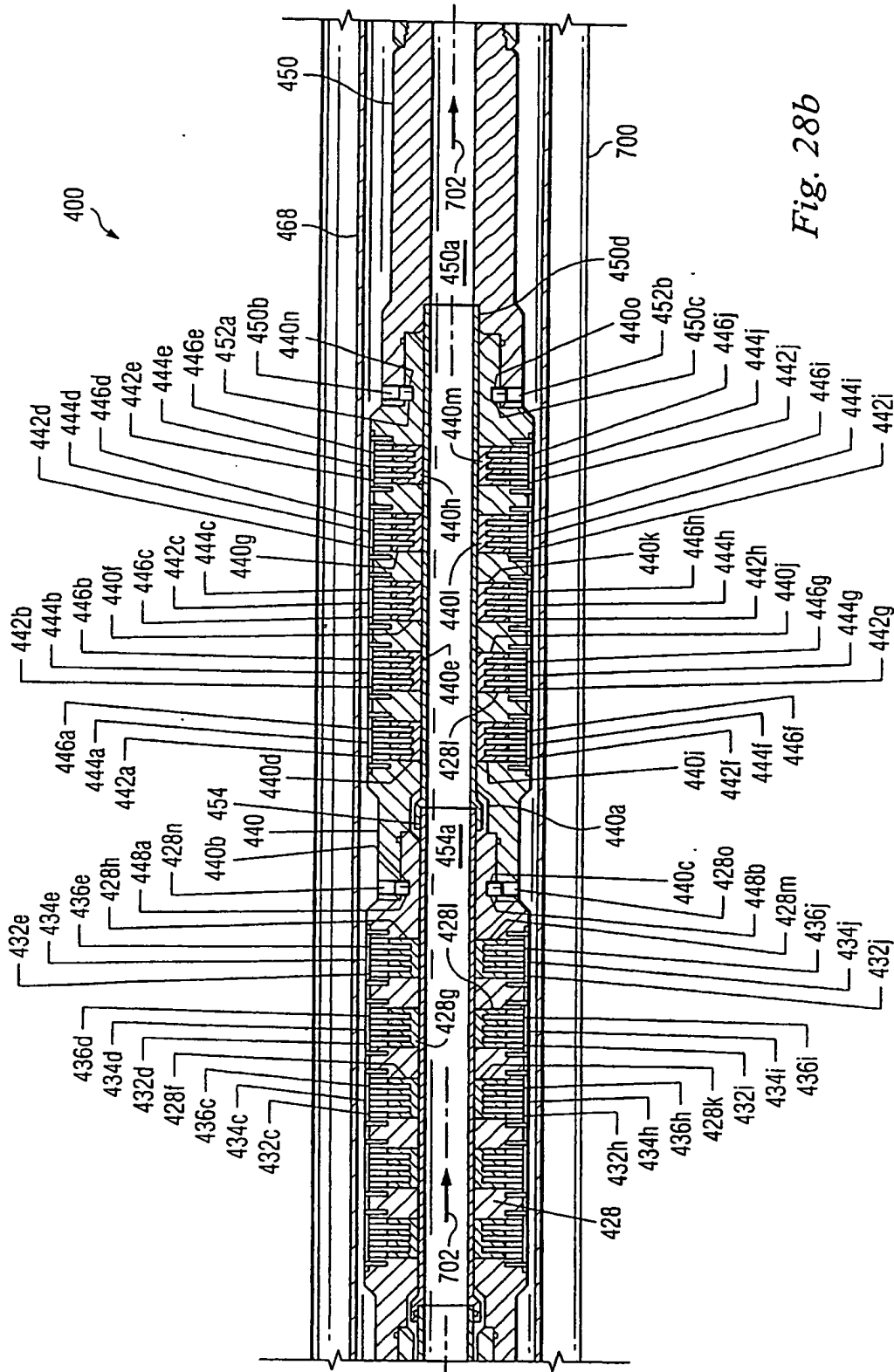


Fig. 28b

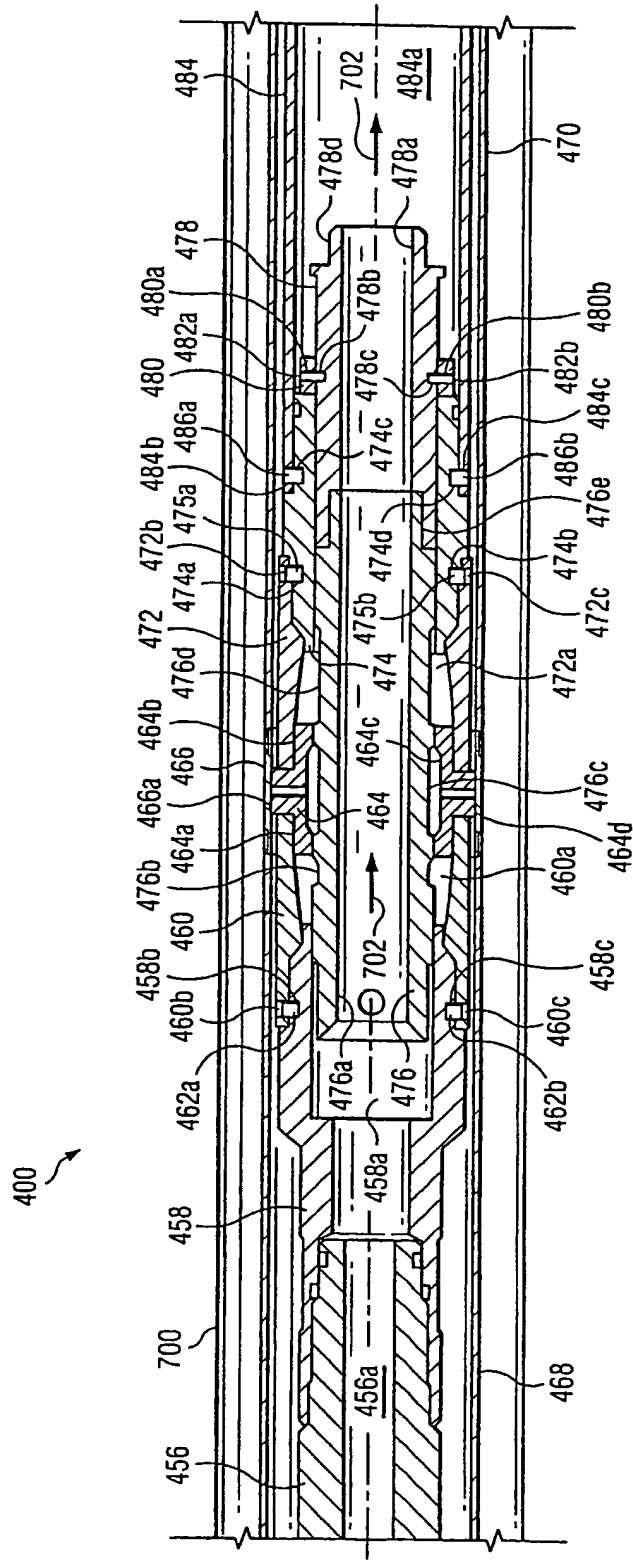


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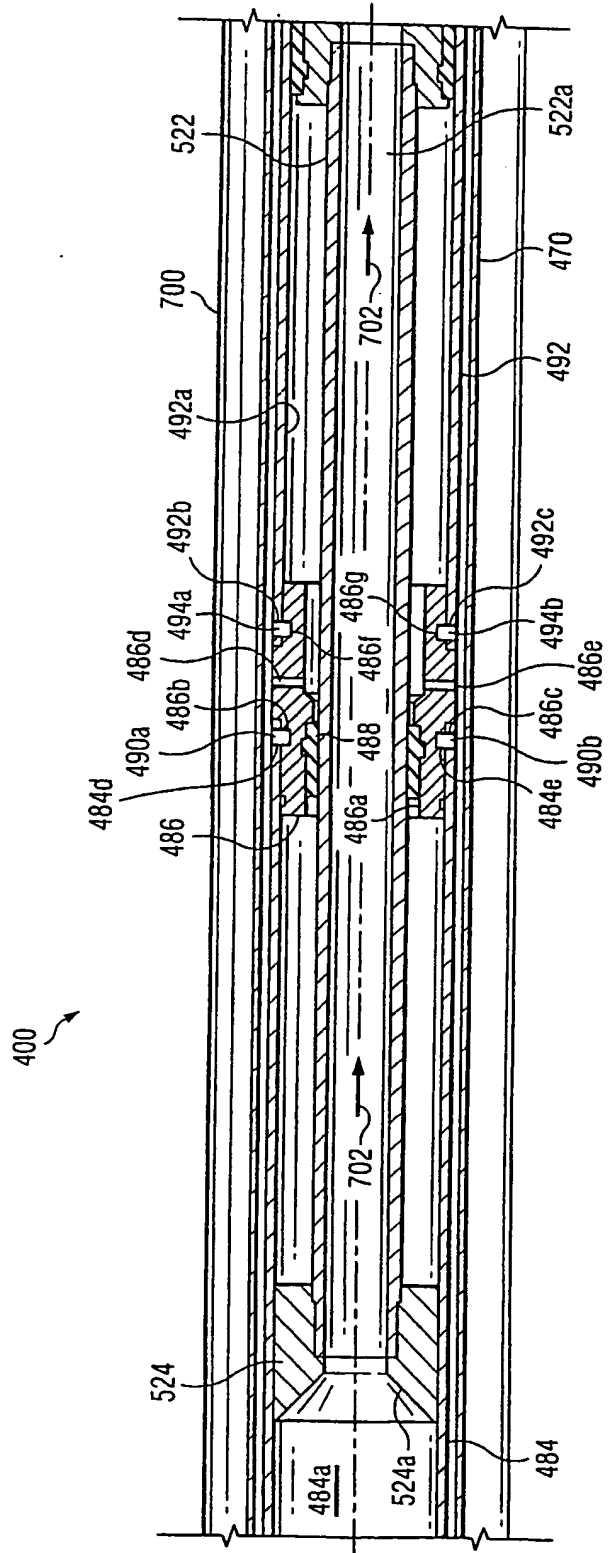


Fig. 28d

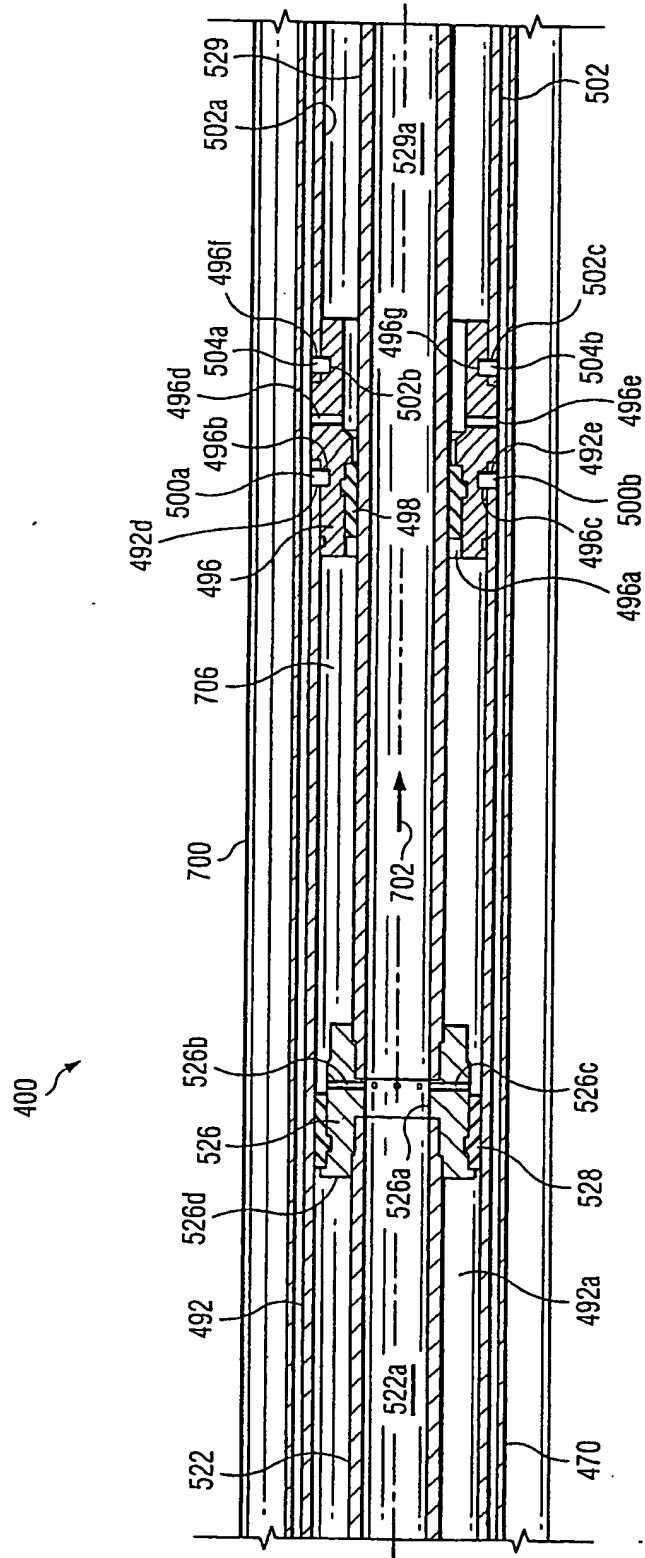


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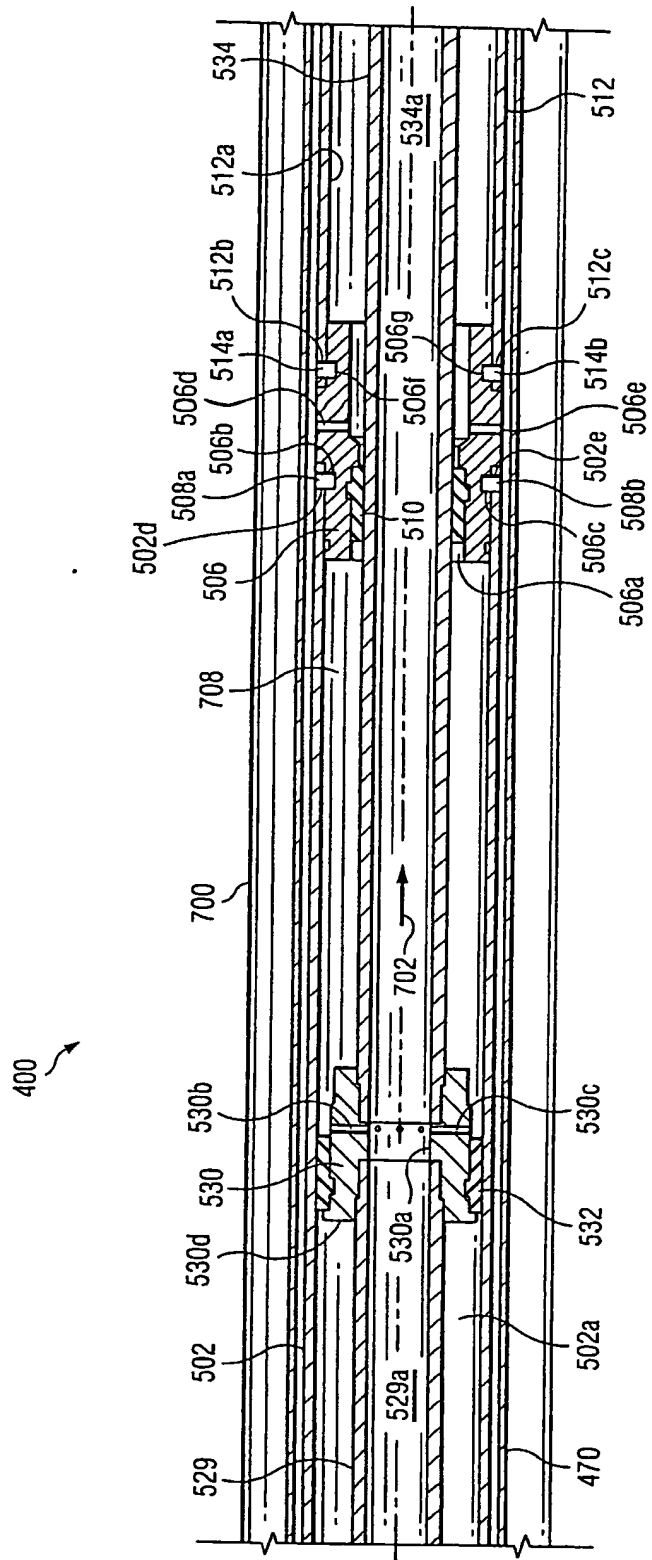


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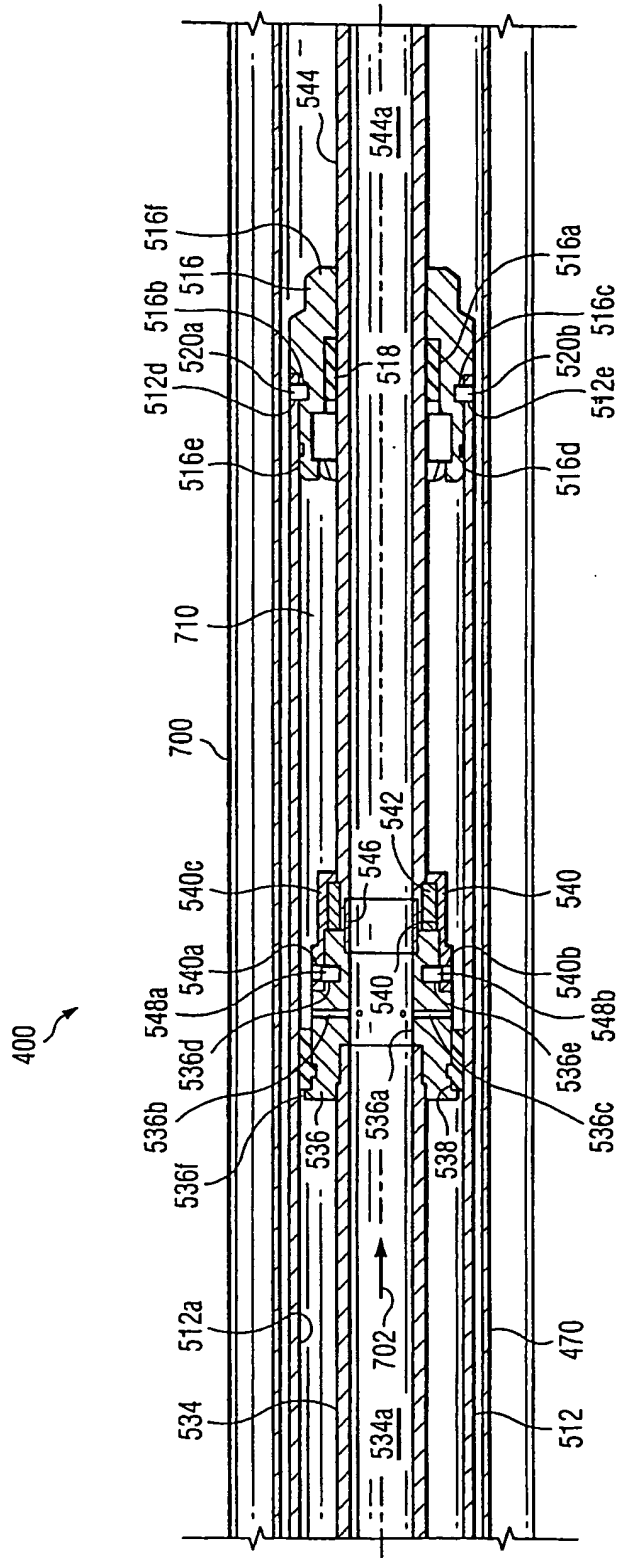


Fig. 28g



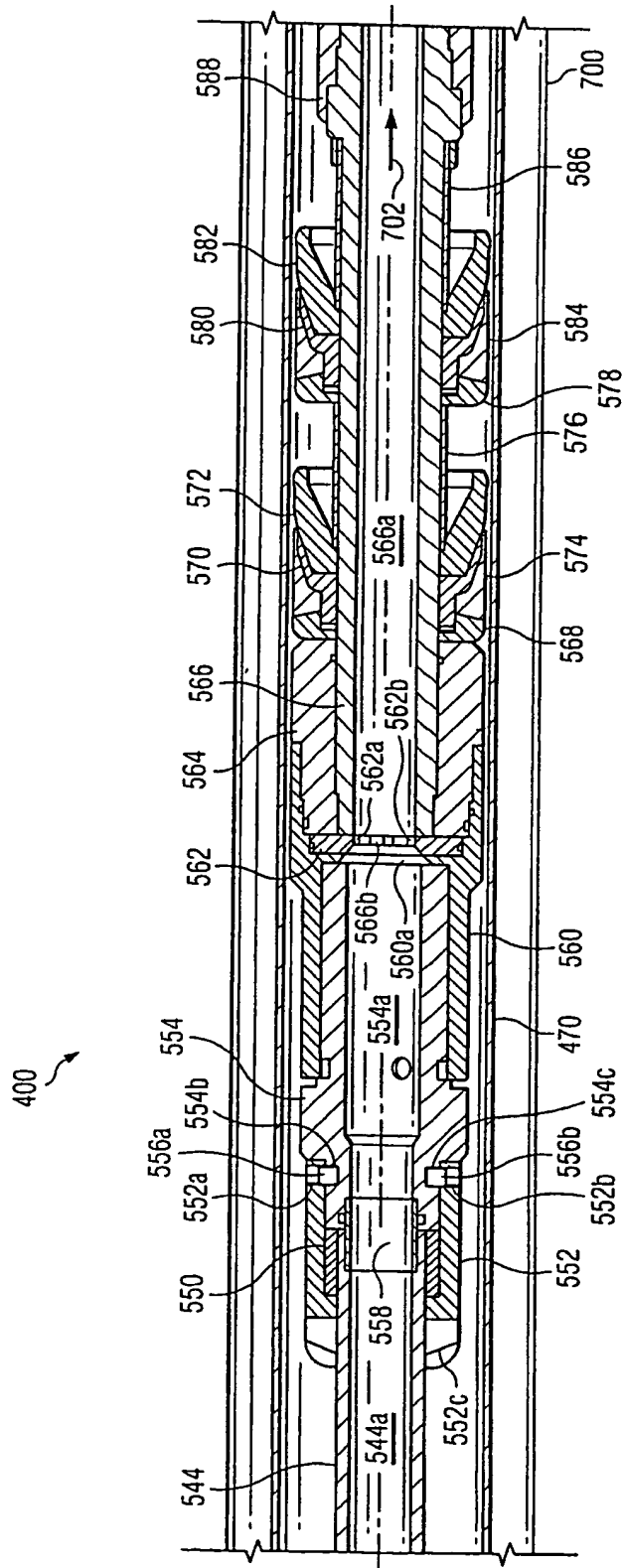


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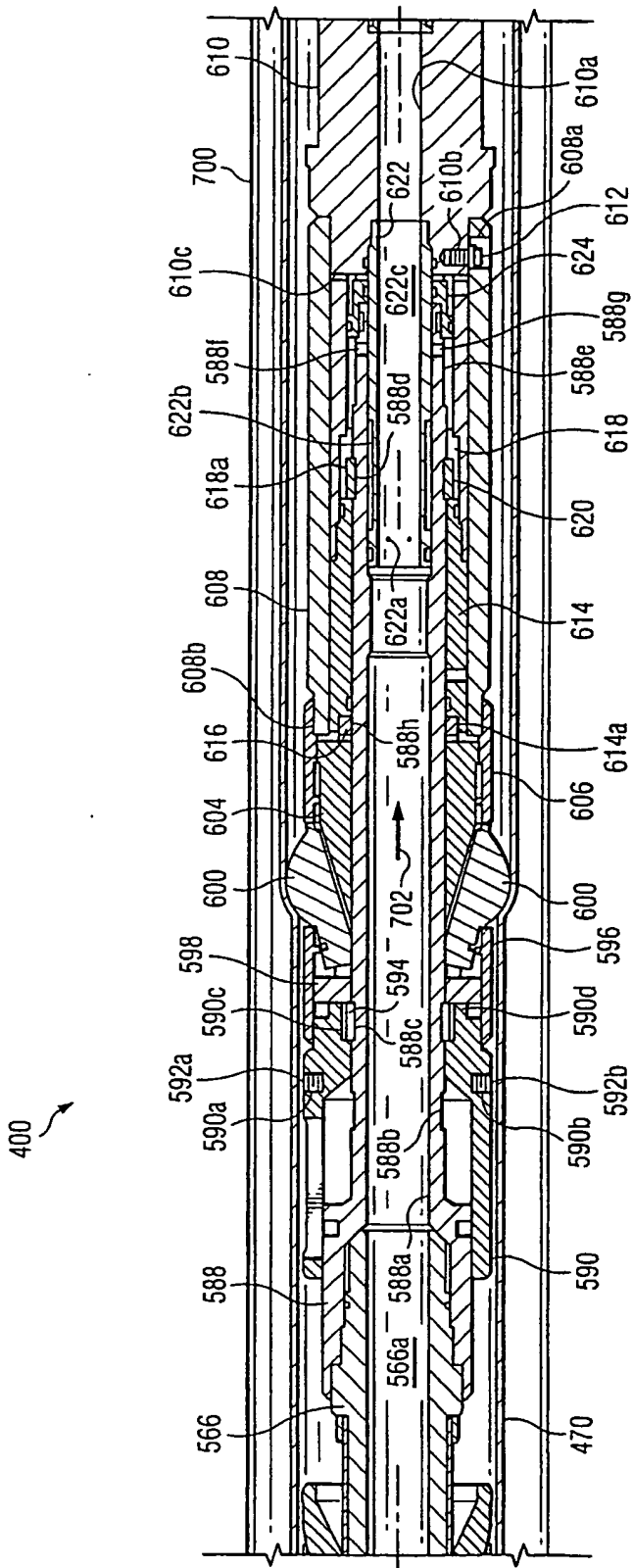


Fig. 28i

400

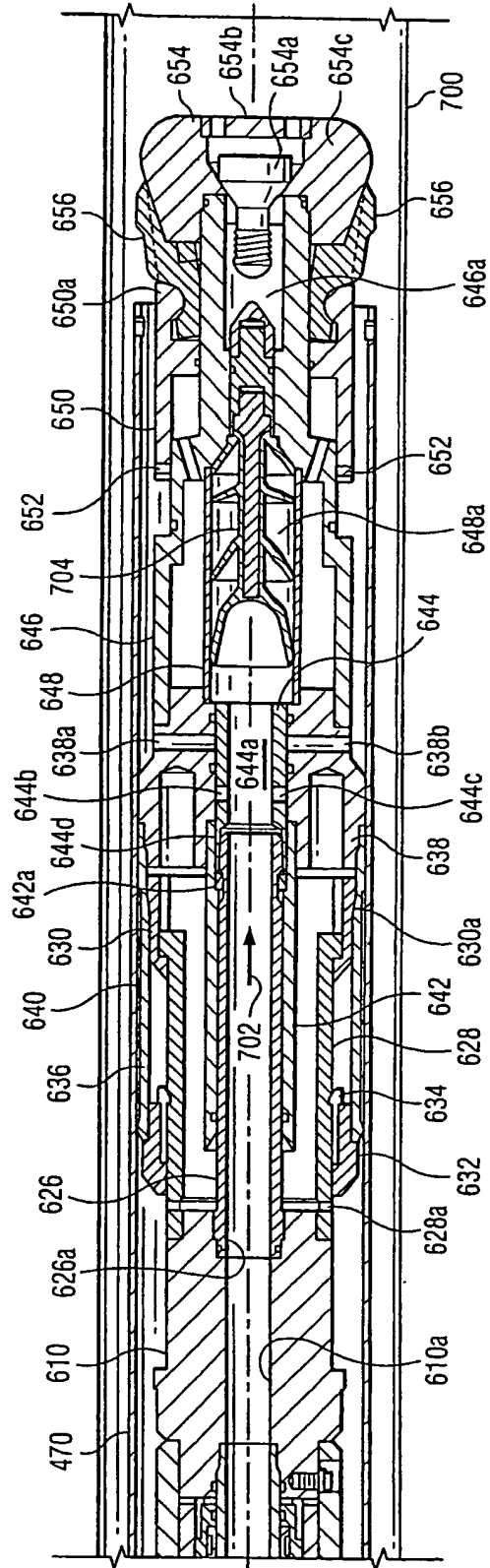


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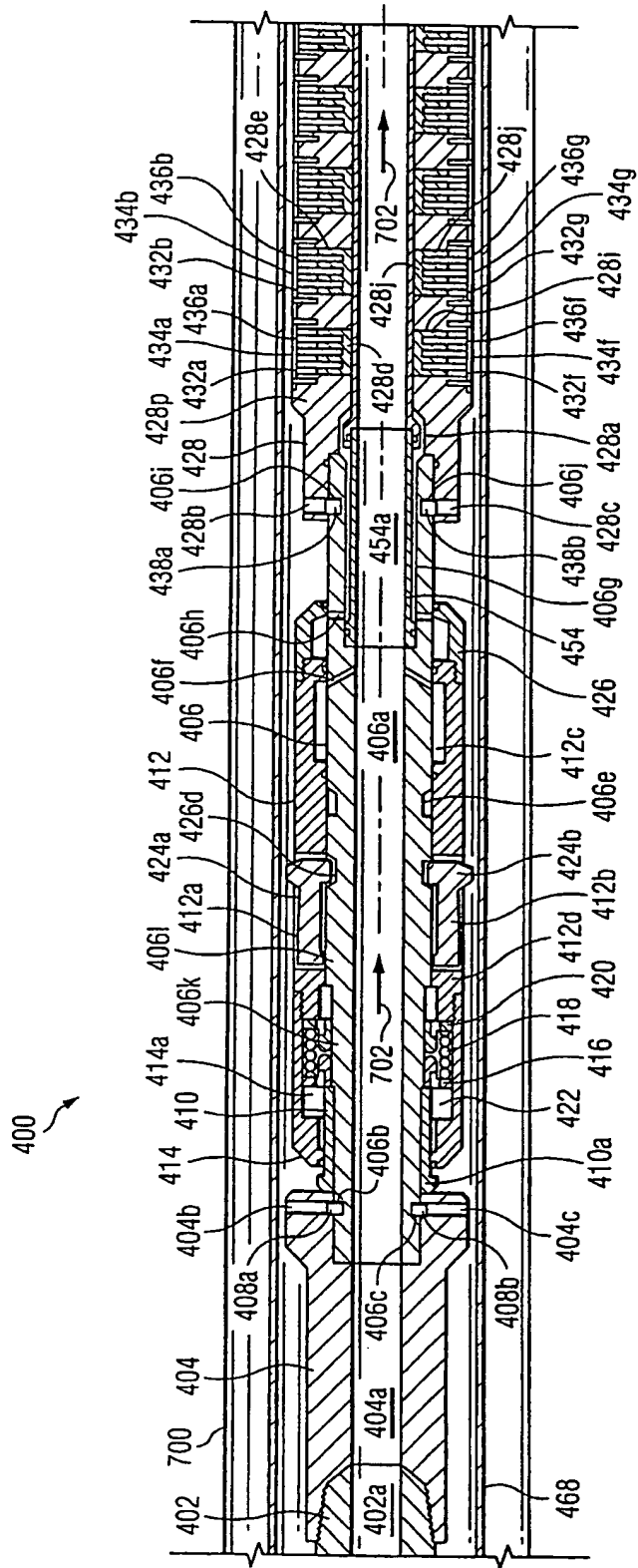


Fig. 29a

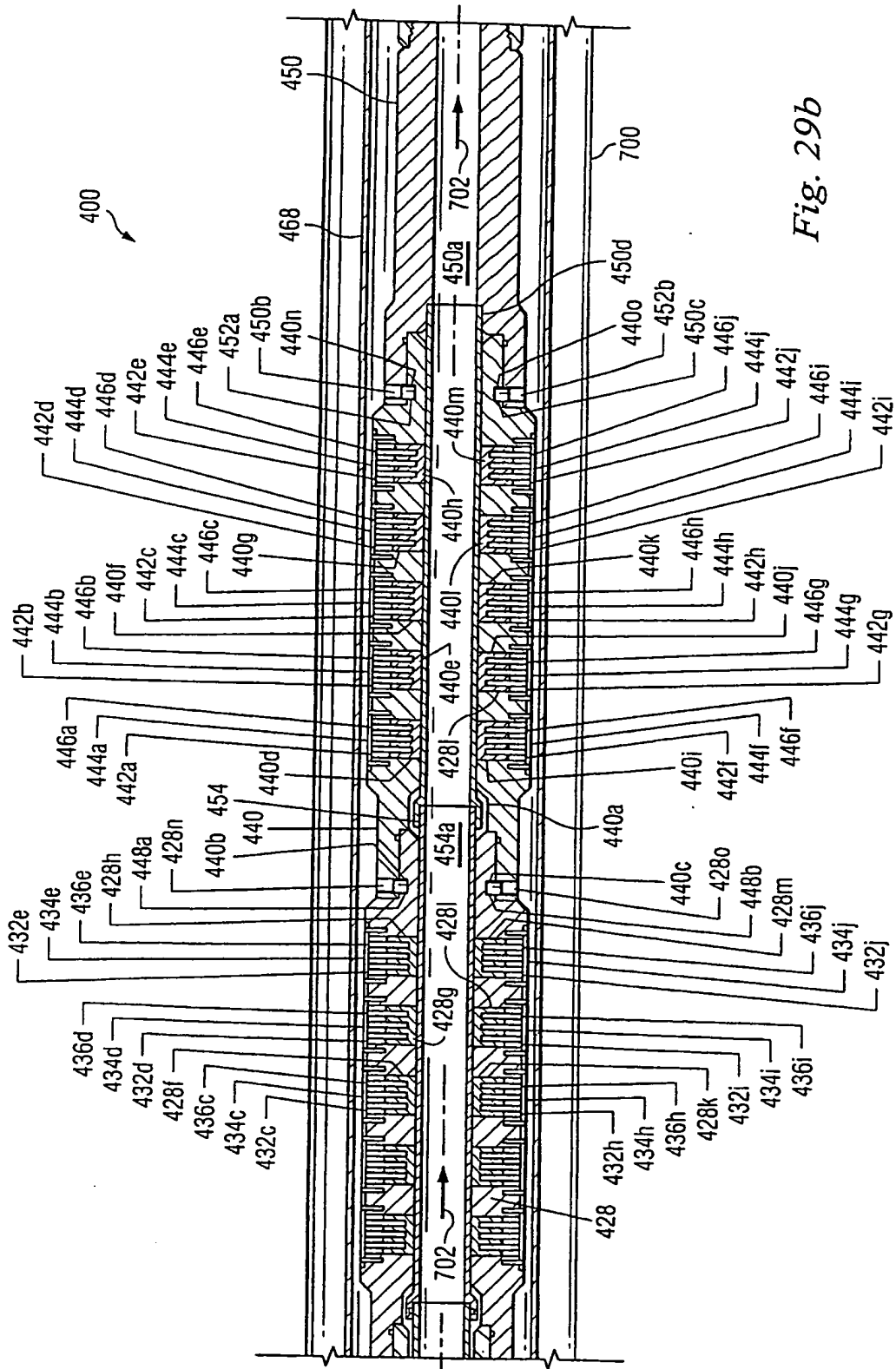


Fig. 29b

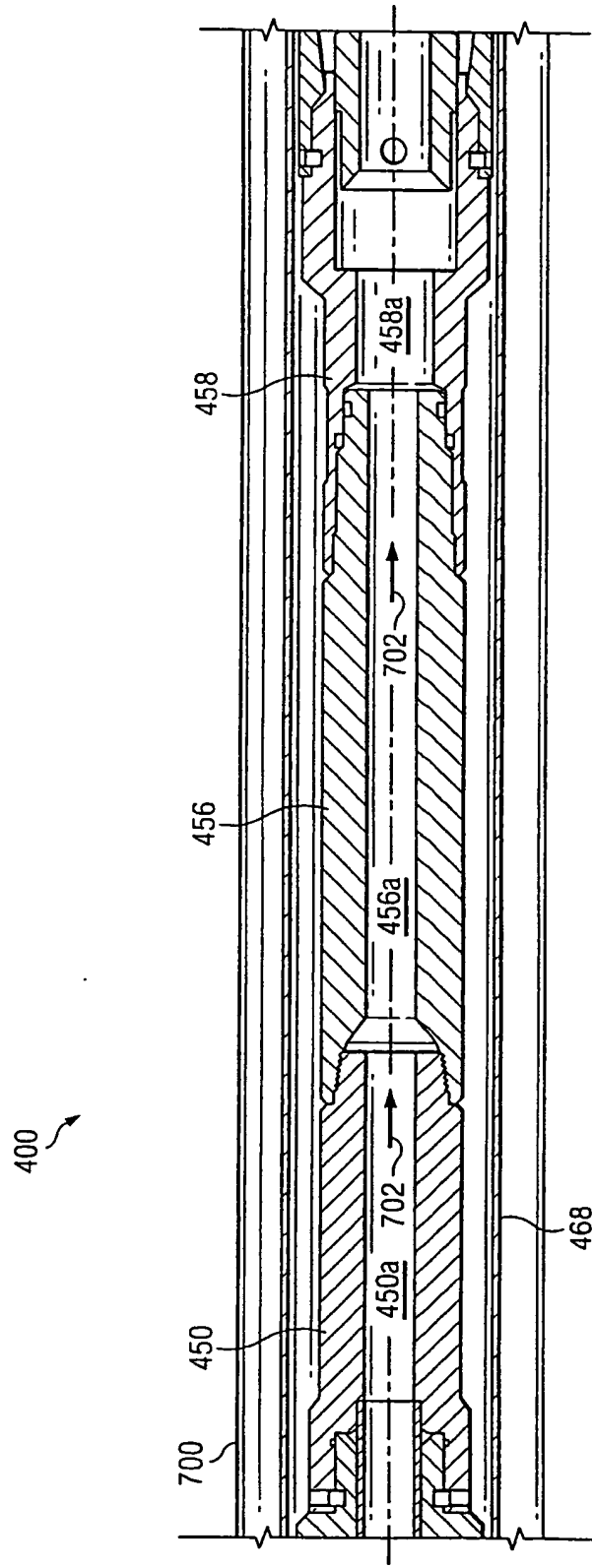


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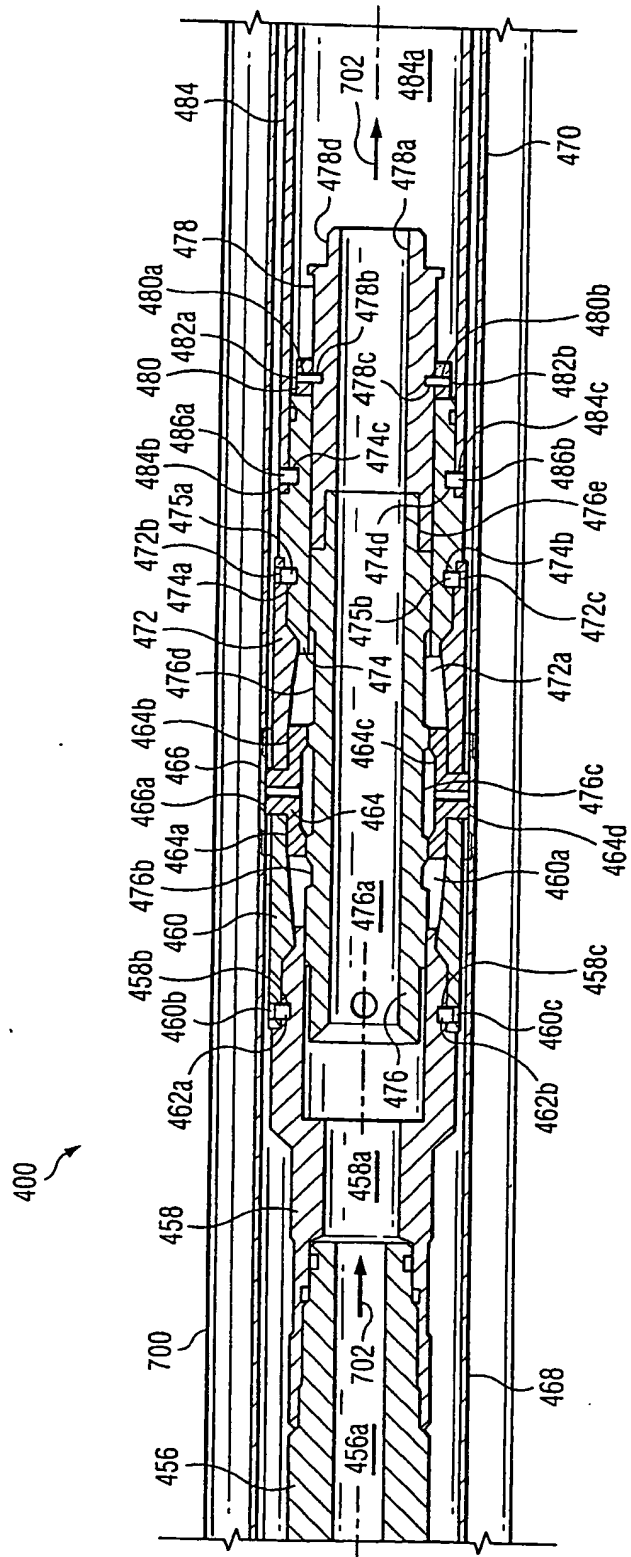


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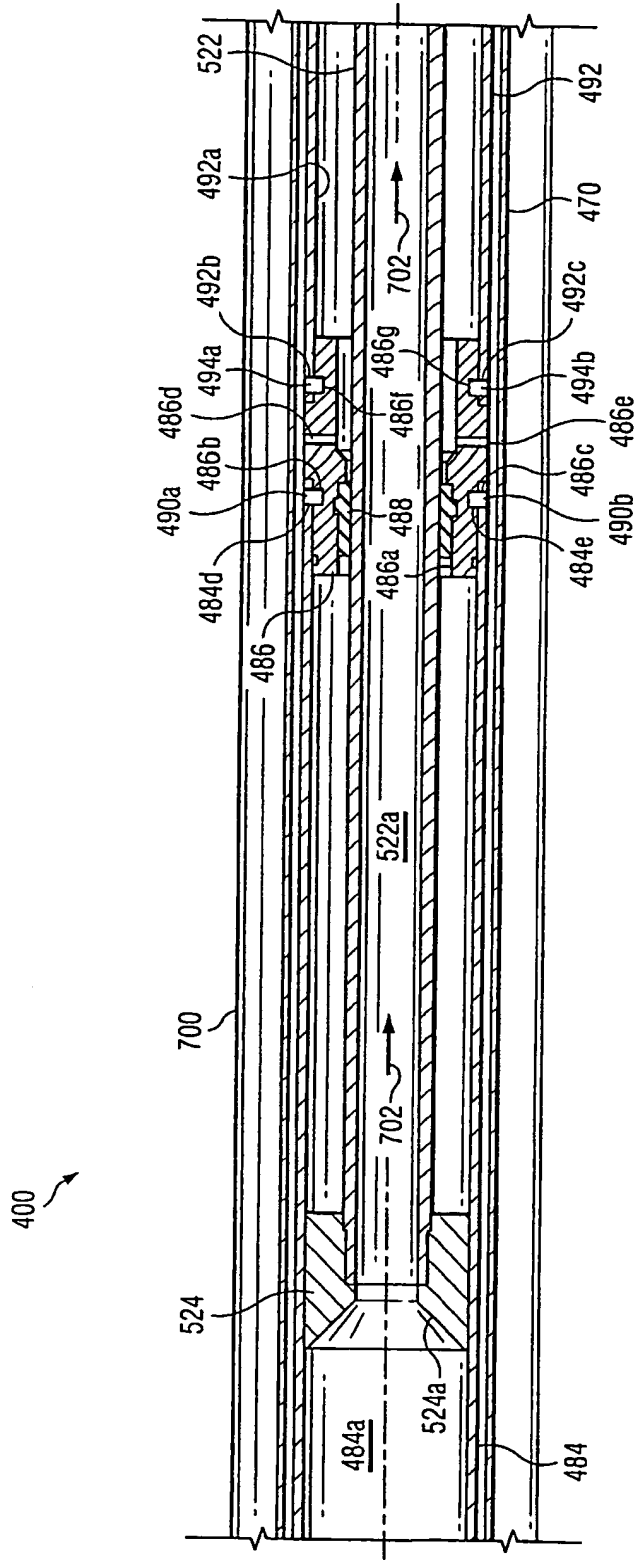


Fig. 29e



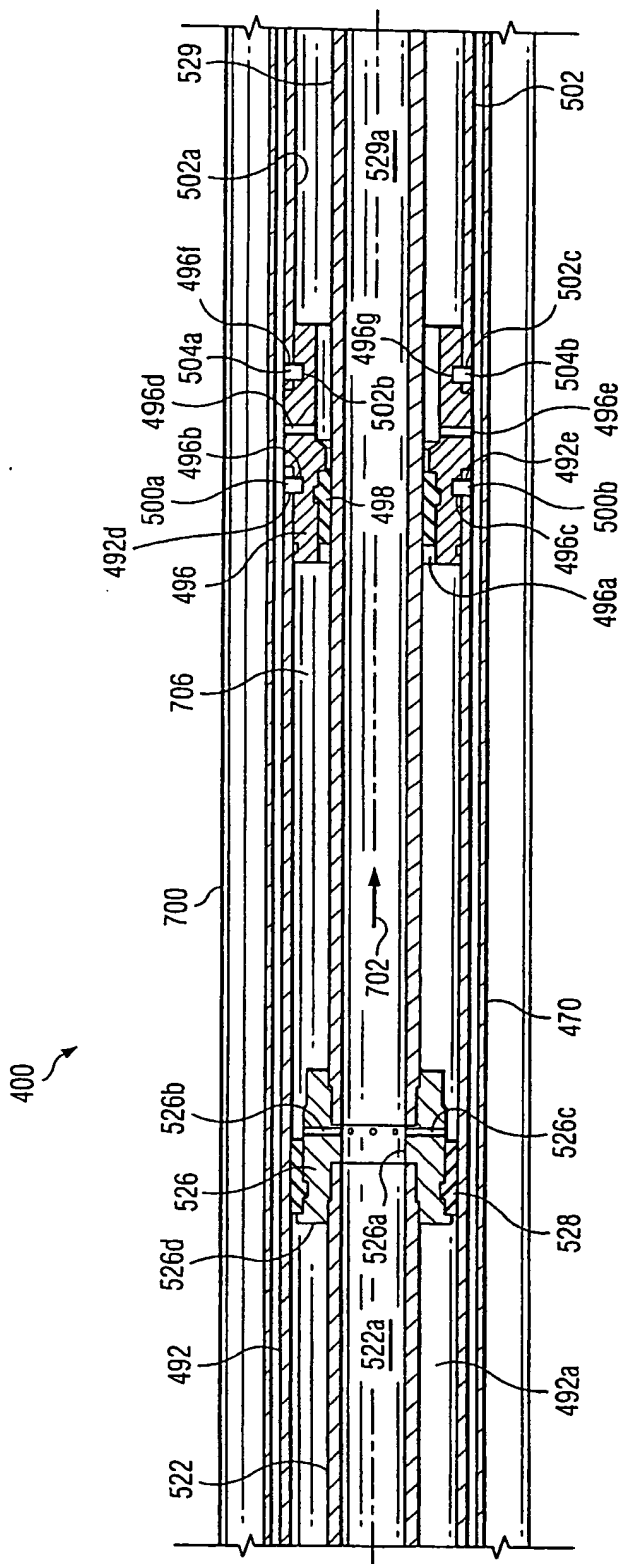


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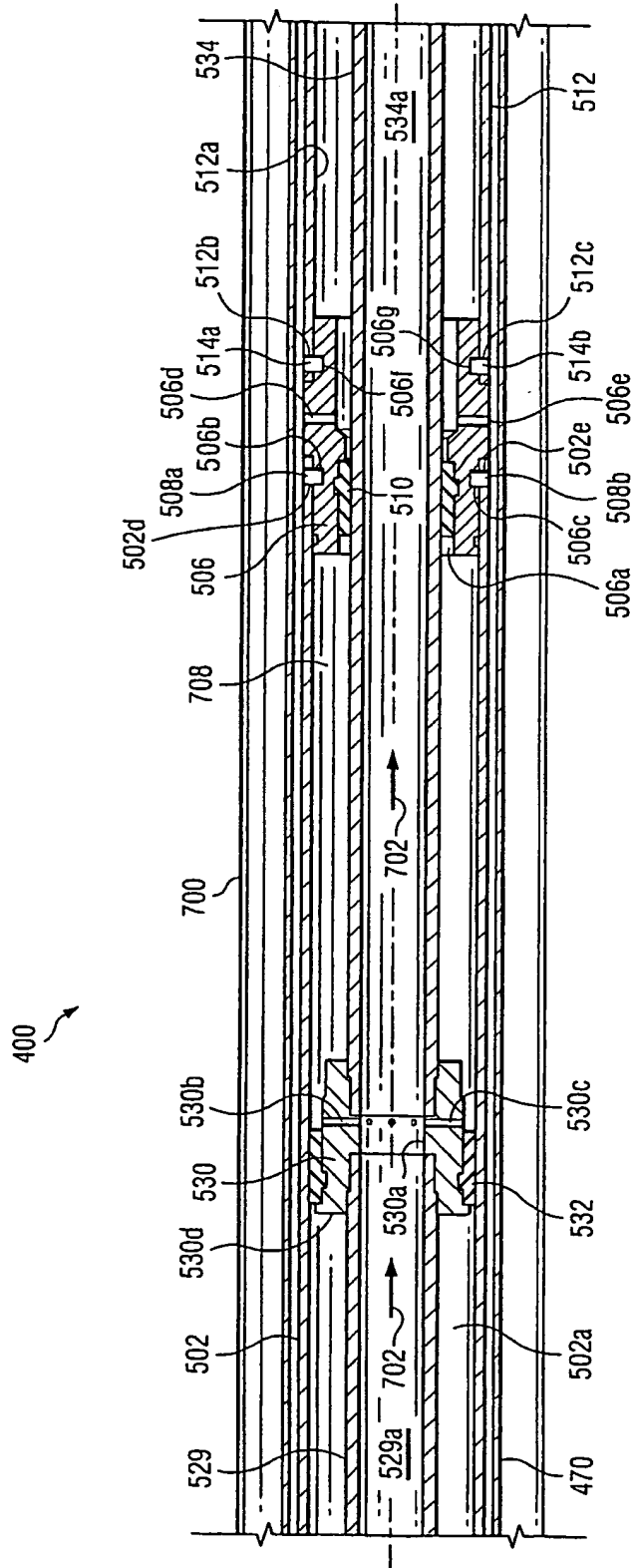


Fig. 29g

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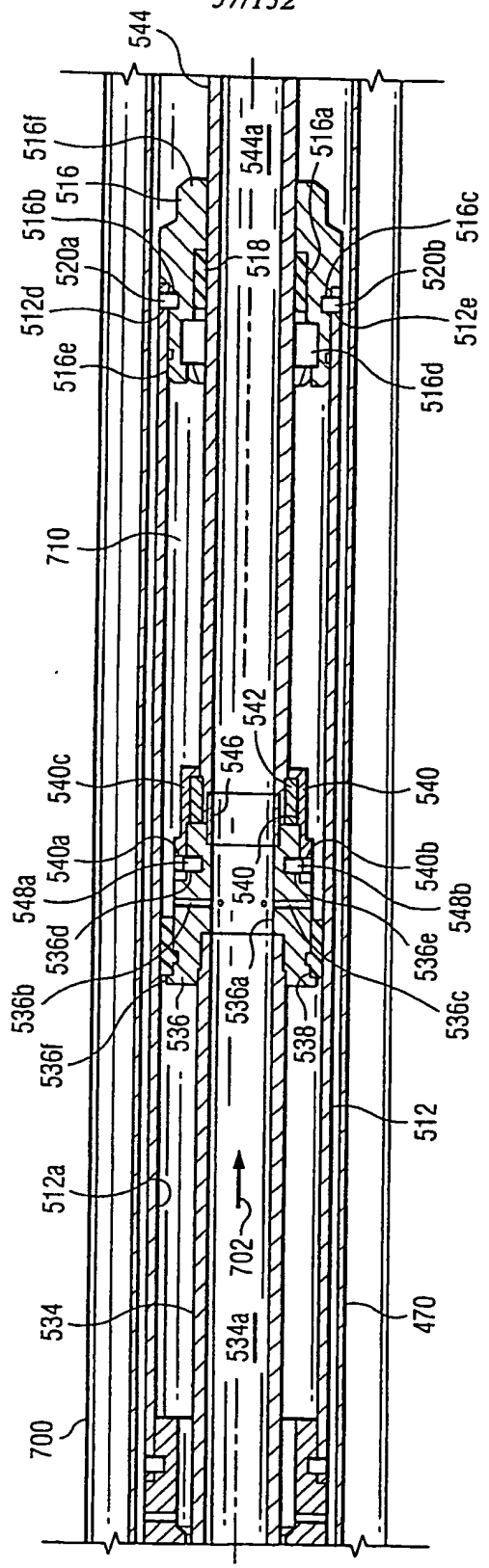


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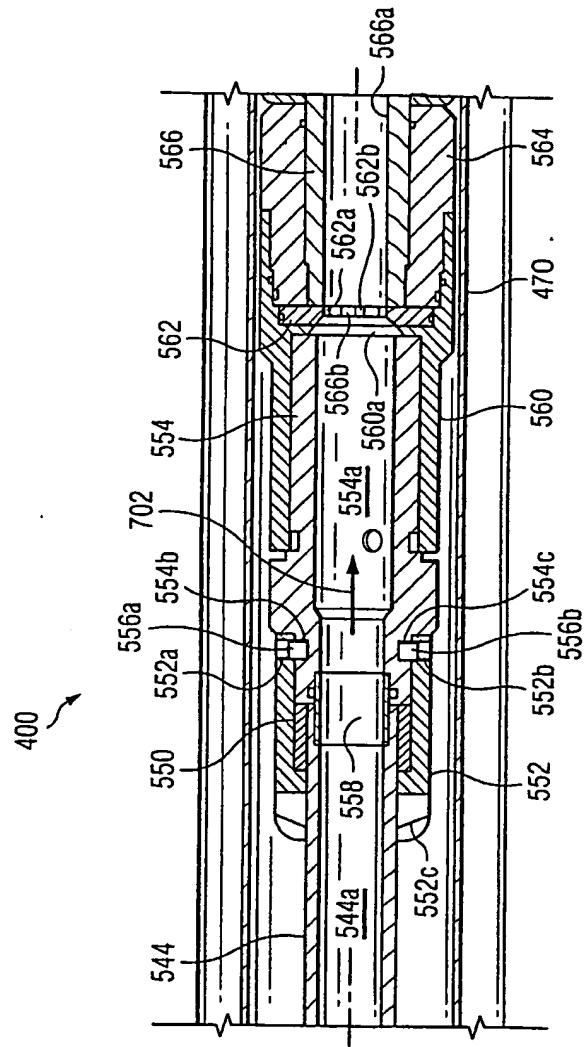


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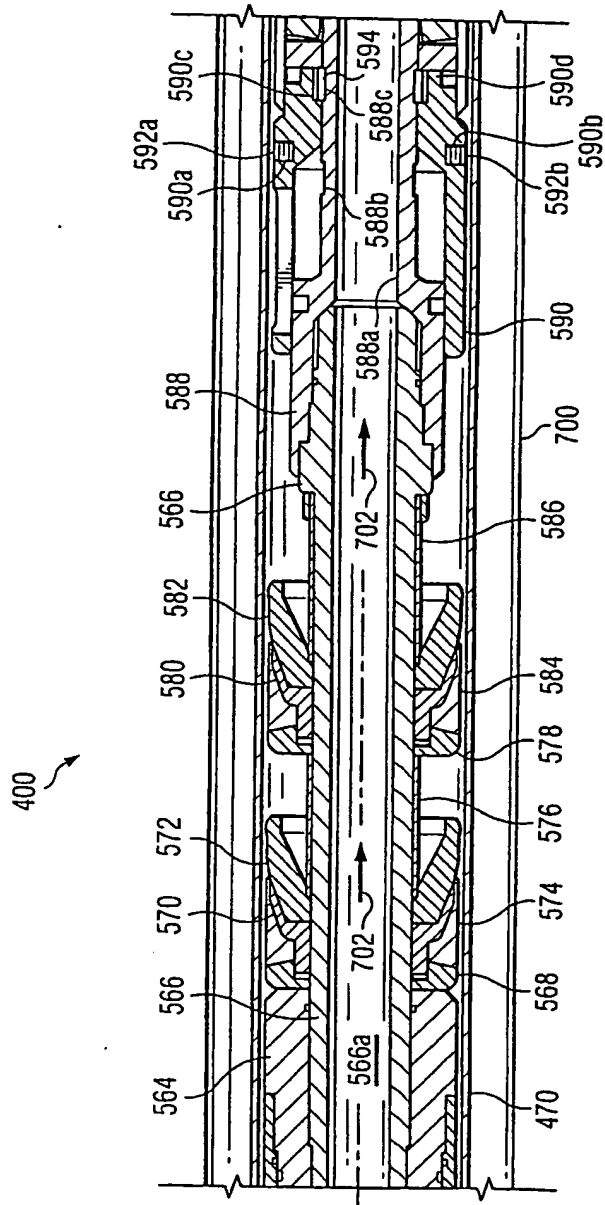


Fig. 29j

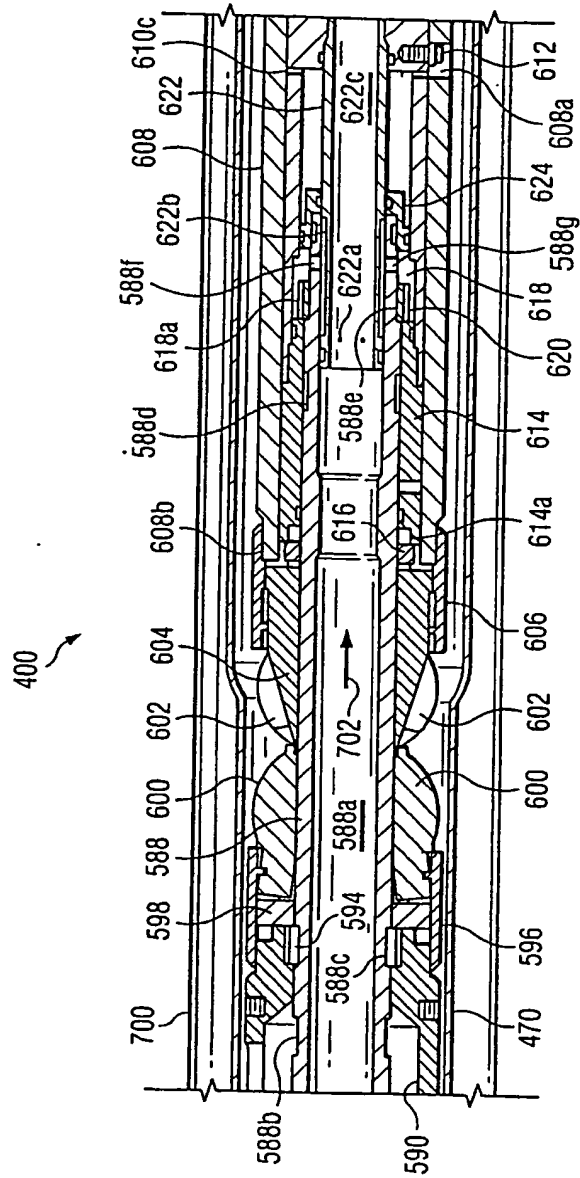


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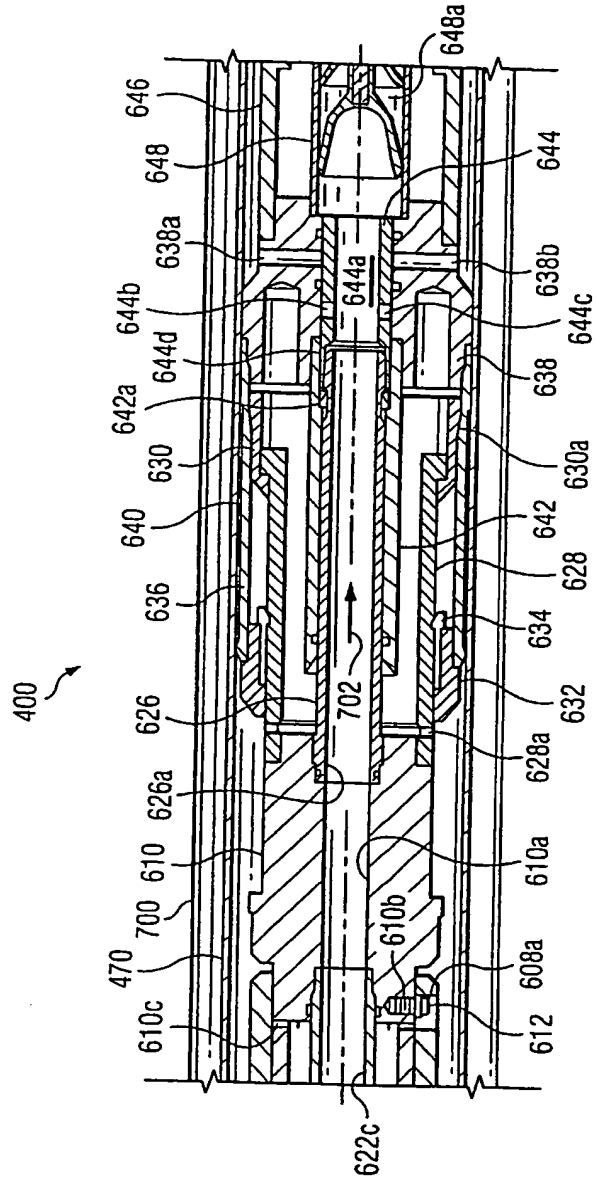


Fig. 291

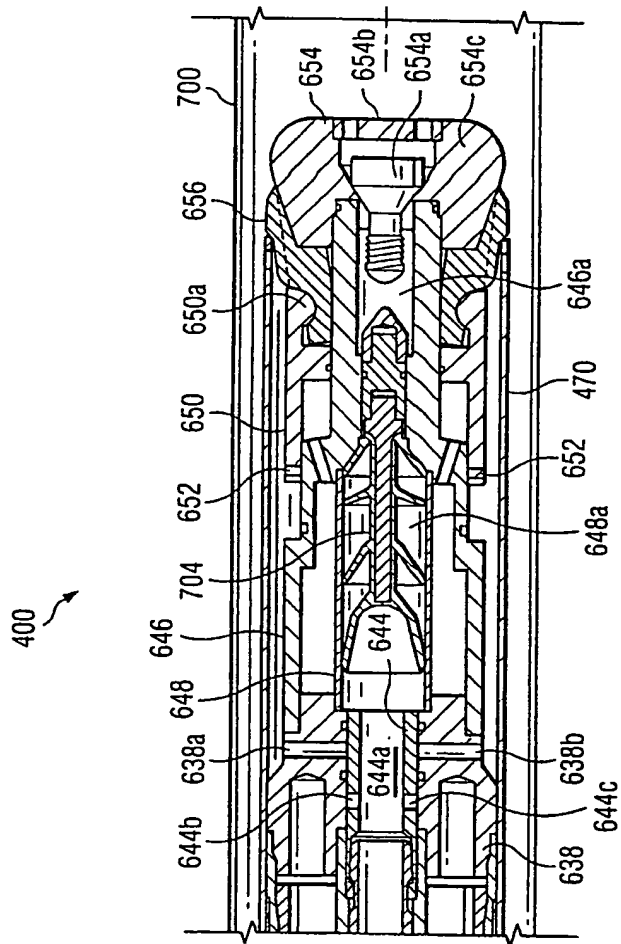


Fig. 29m



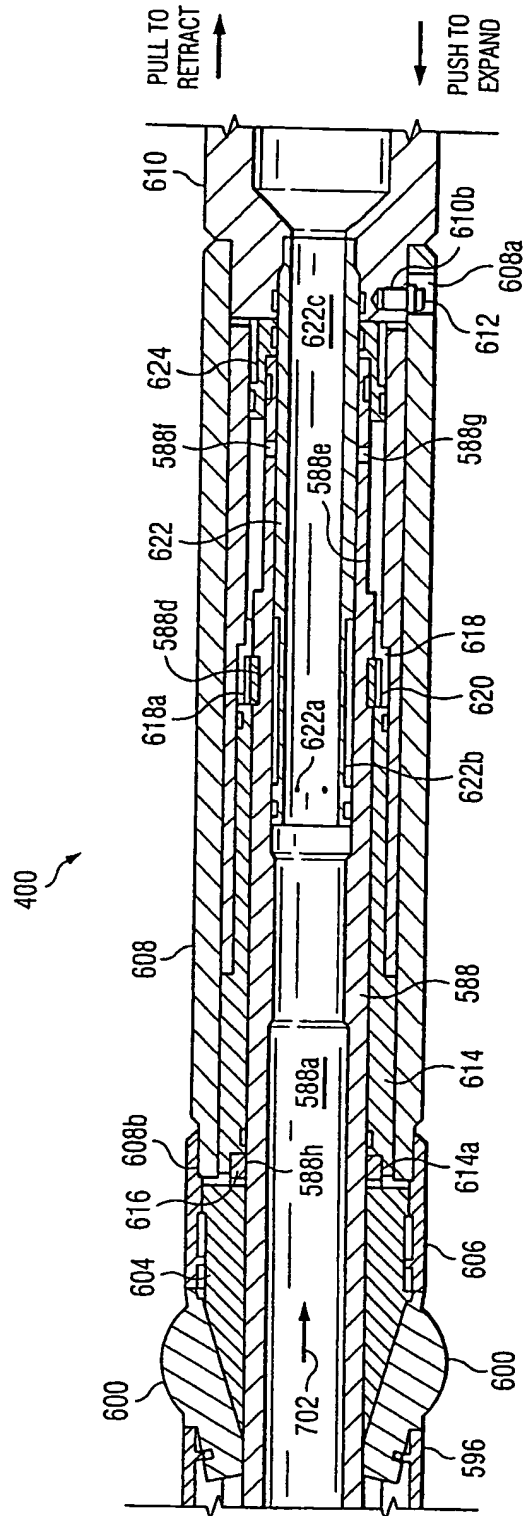


Fig. 30a

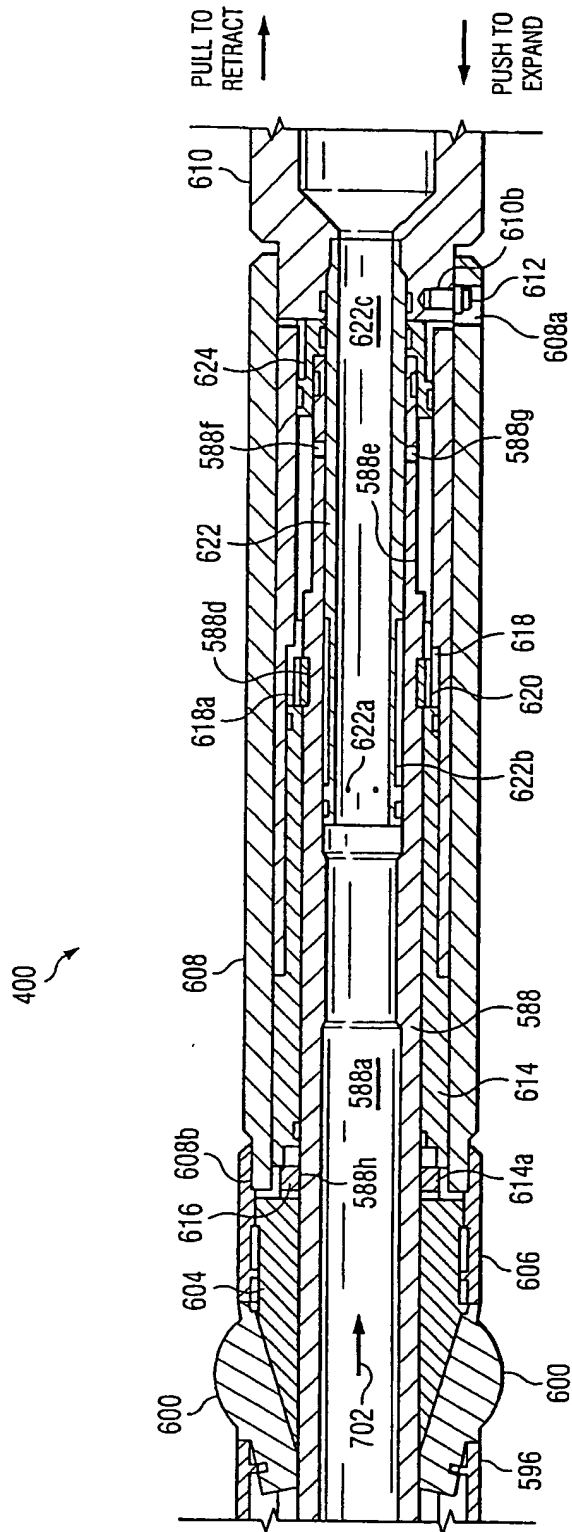


Fig. 30b

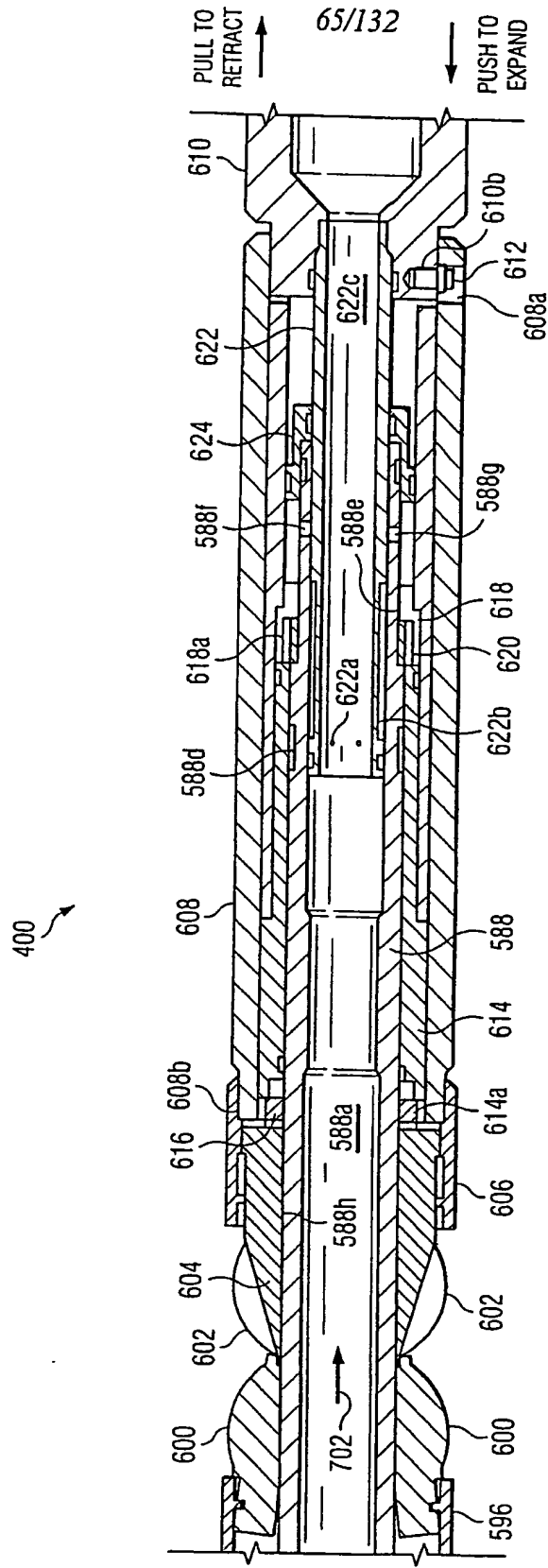


Fig. 30c

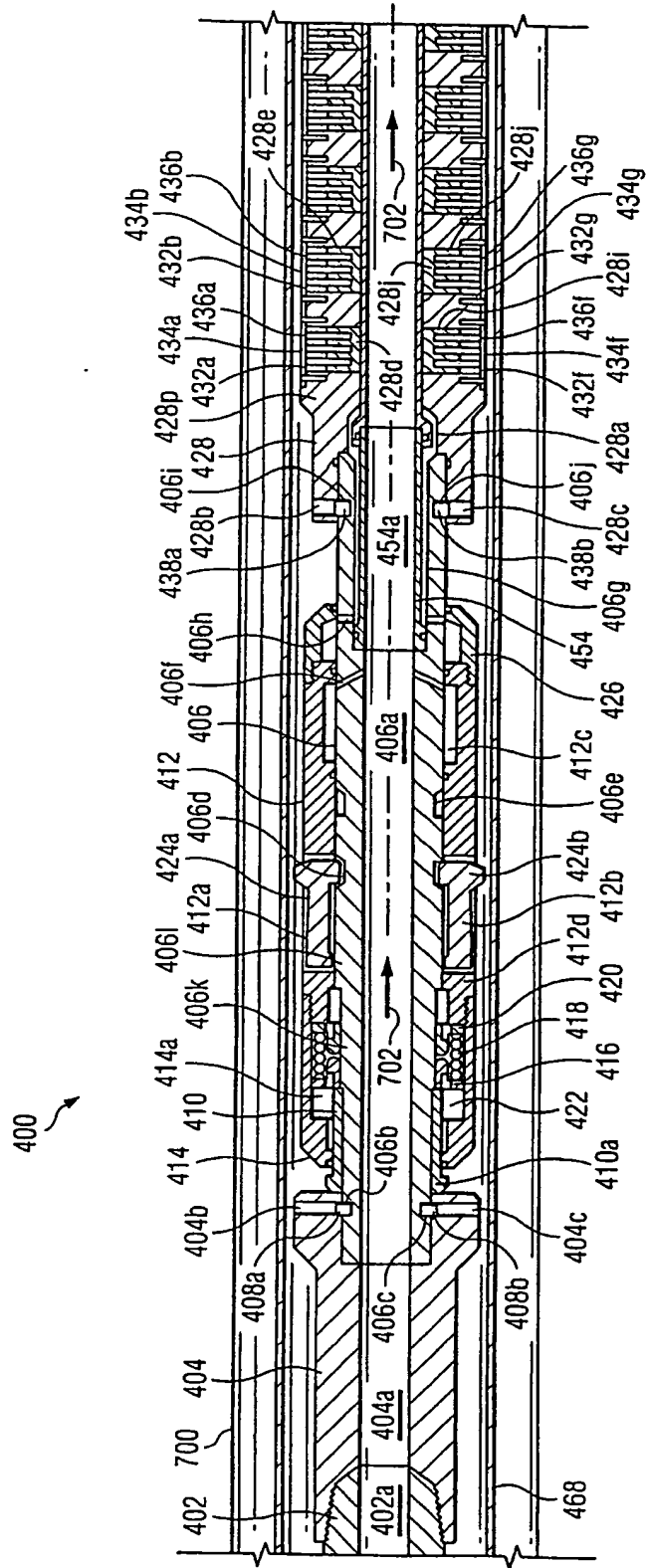


Fig. 31a

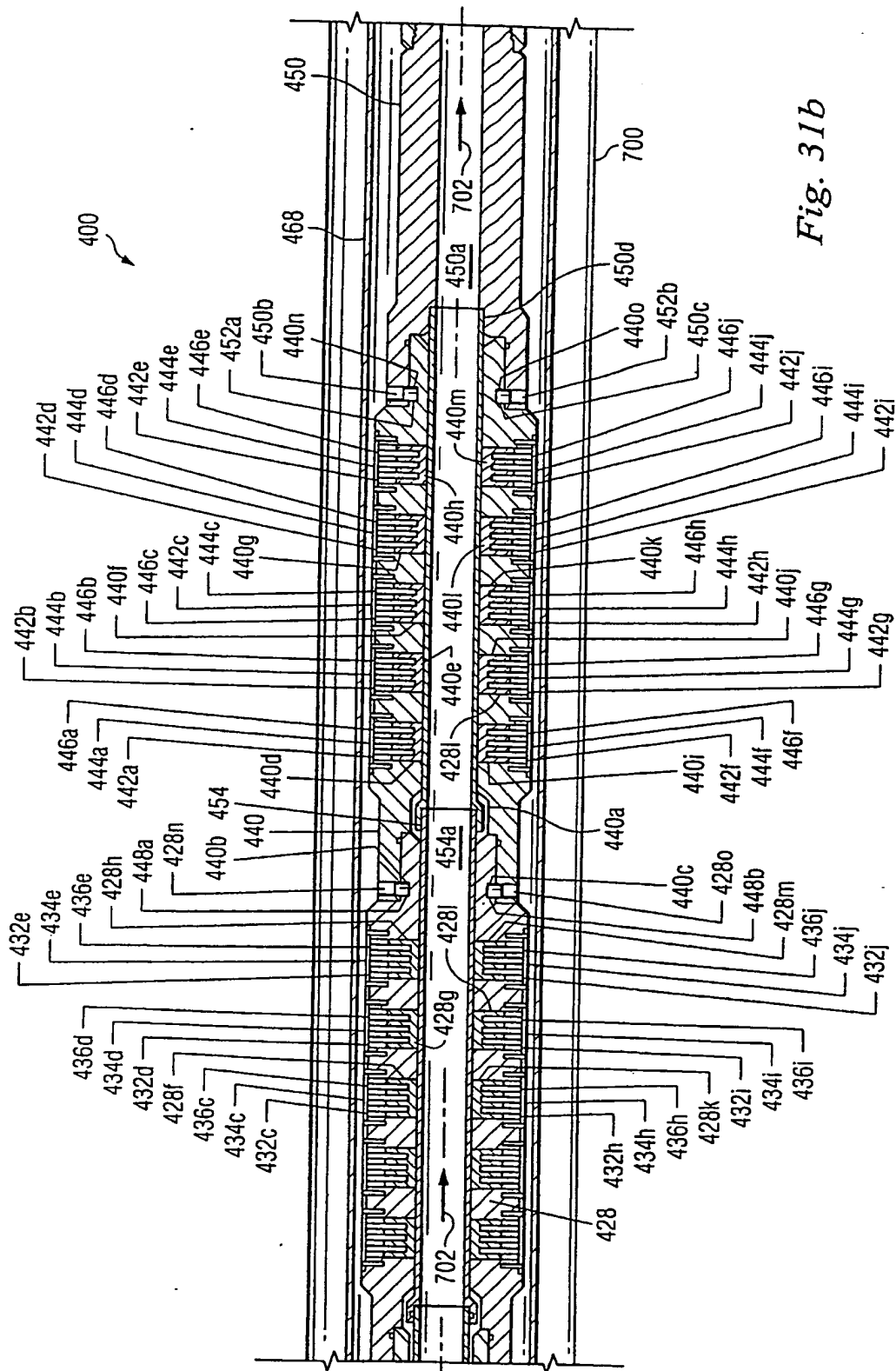


Fig. 31b

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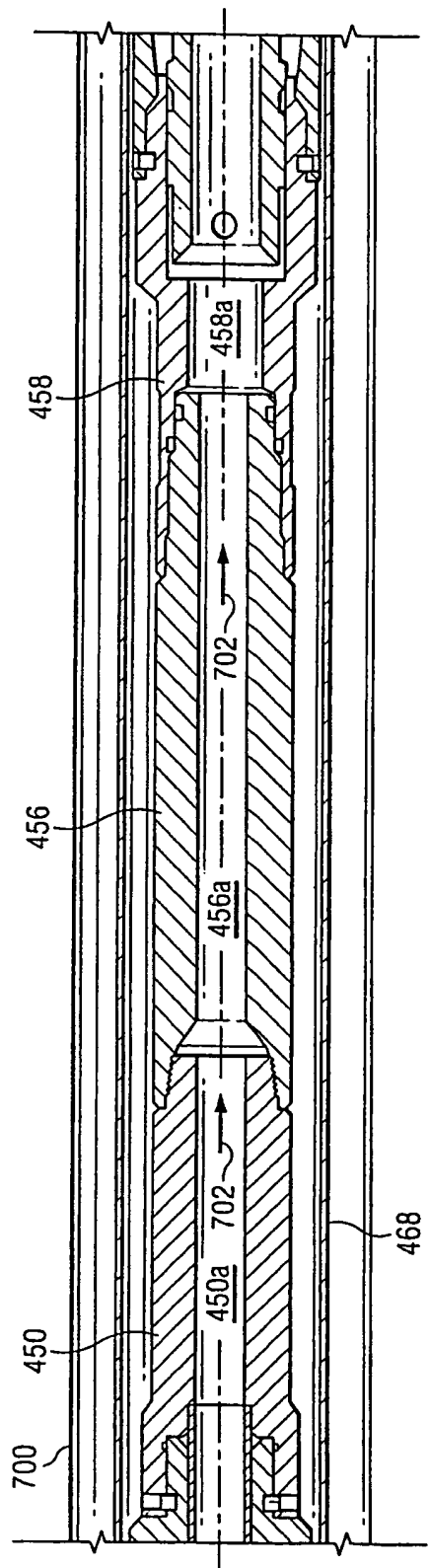


Fig. 31c

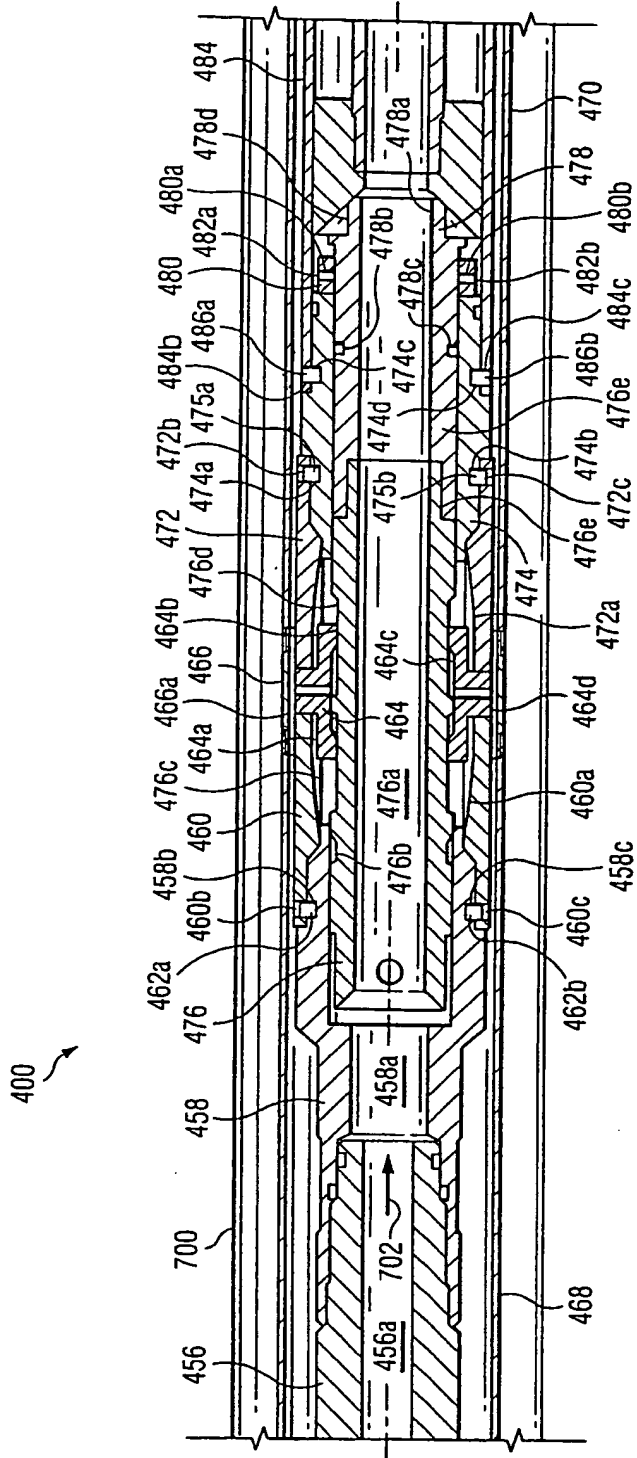


Fig. 31d

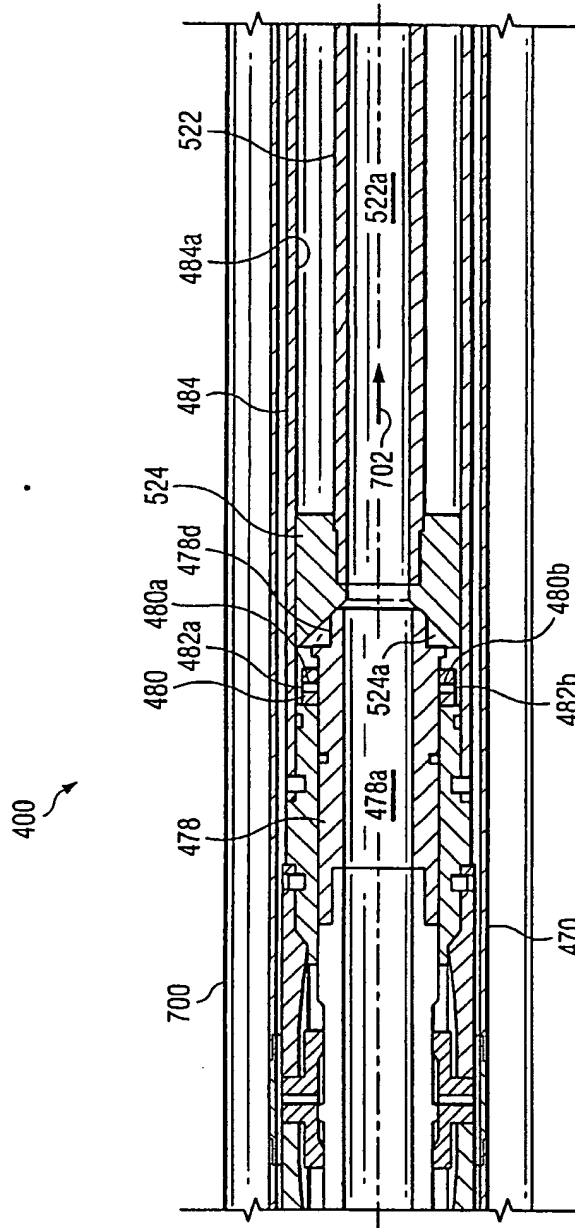


Fig. 31e



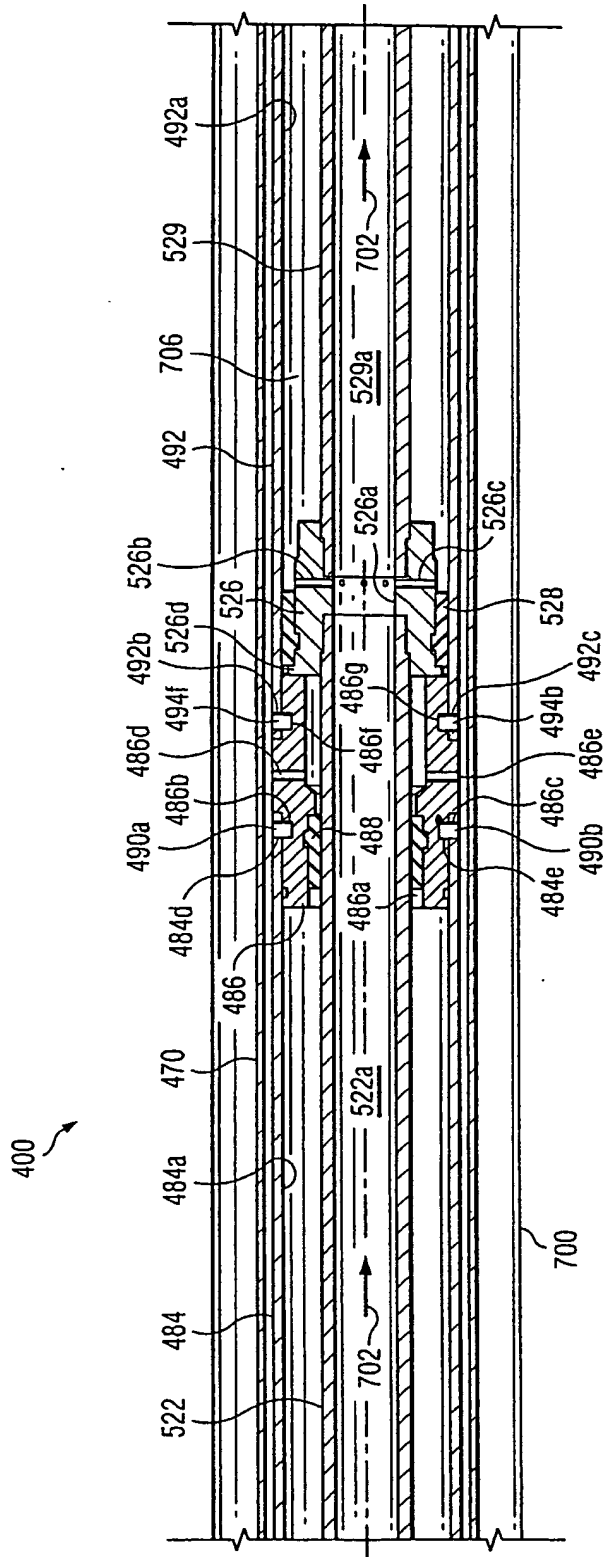


Fig. 31f

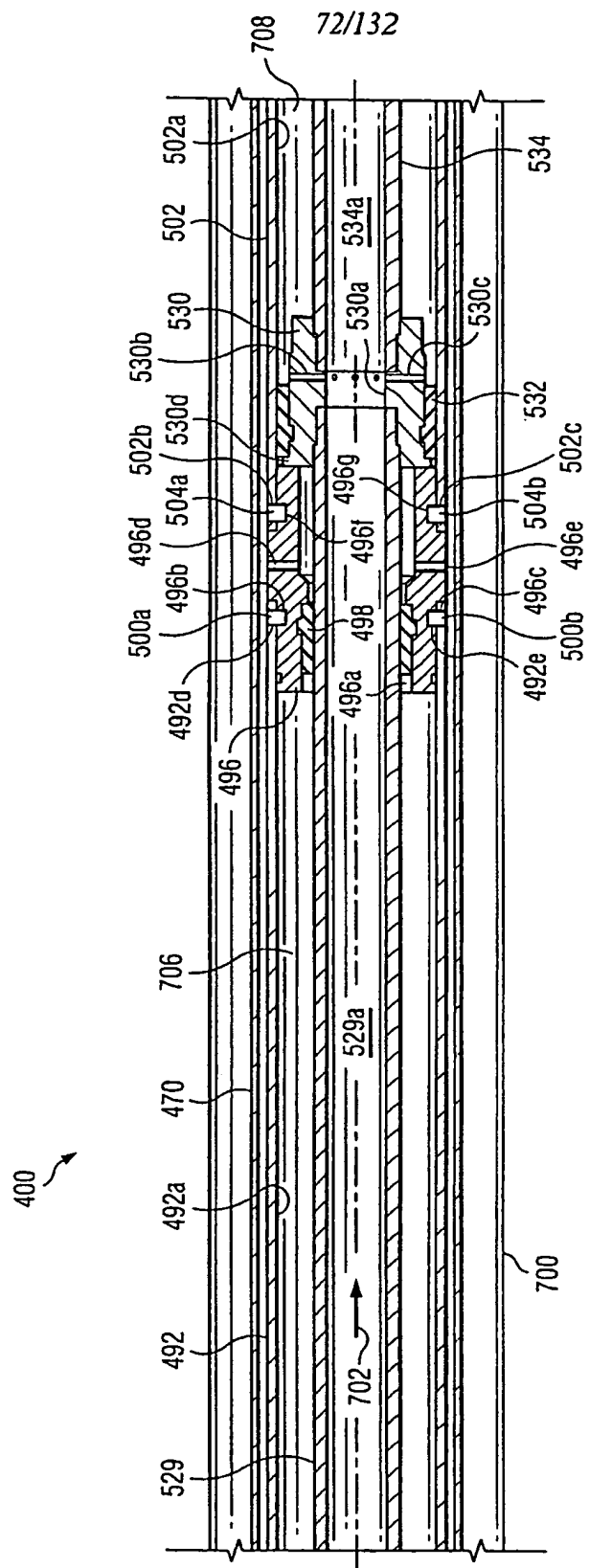


Fig. 31g

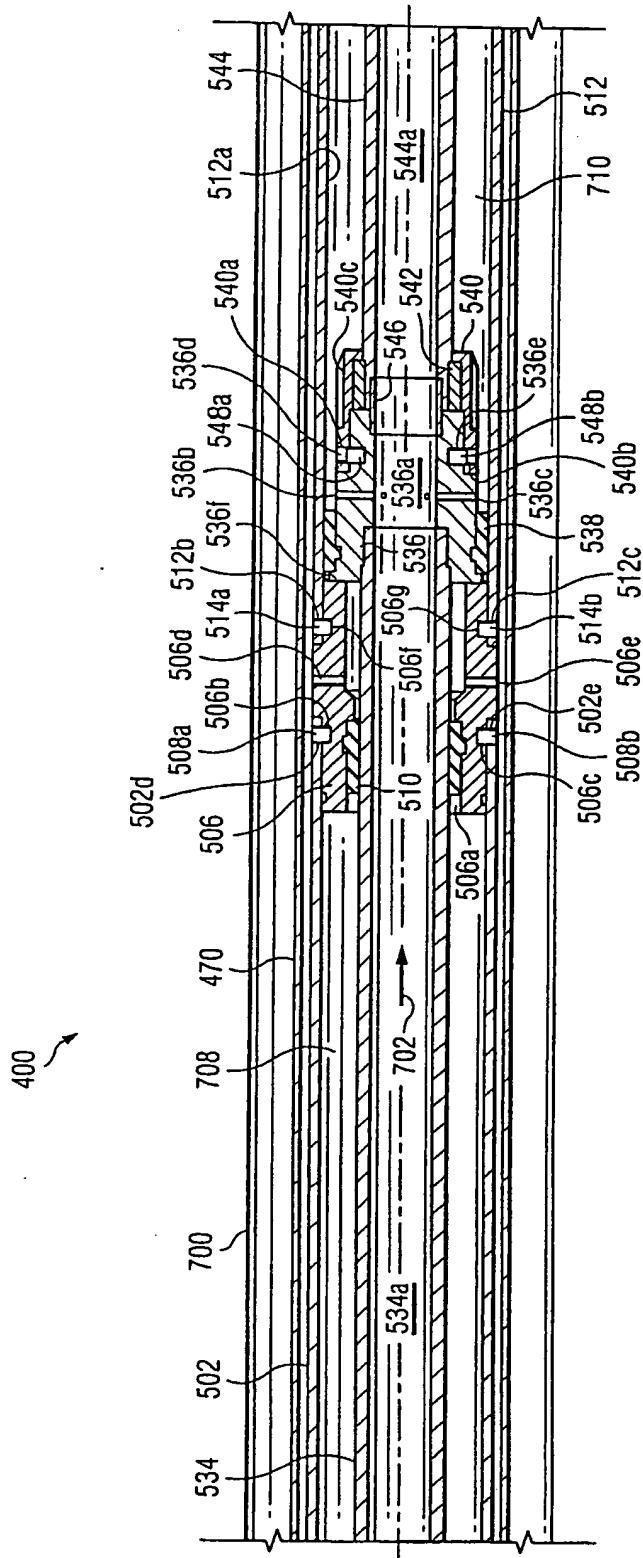


Fig. 31h

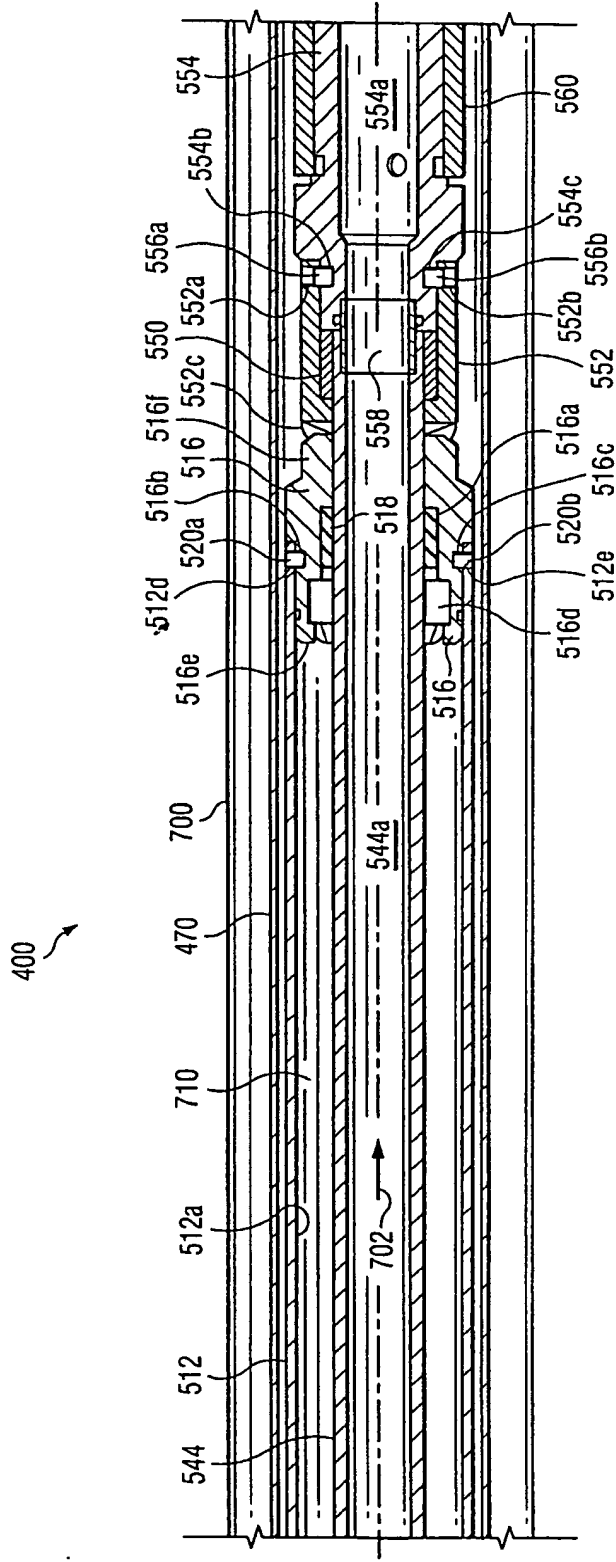
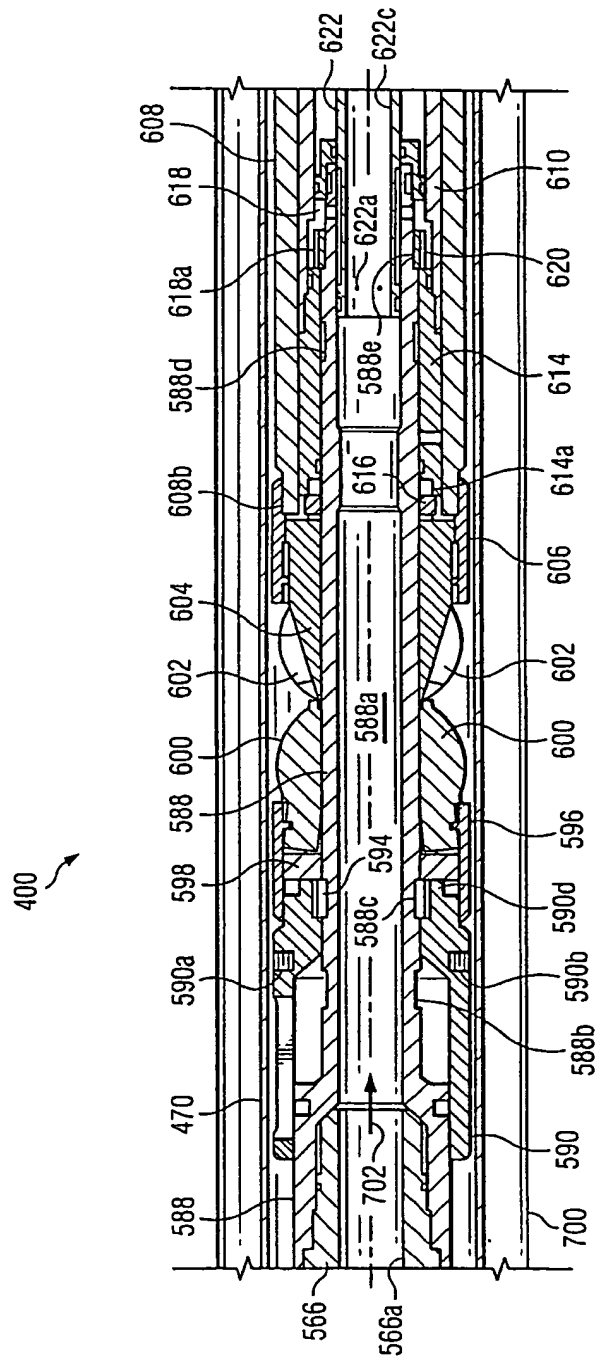


Fig. 31i





*Fig. 31k*

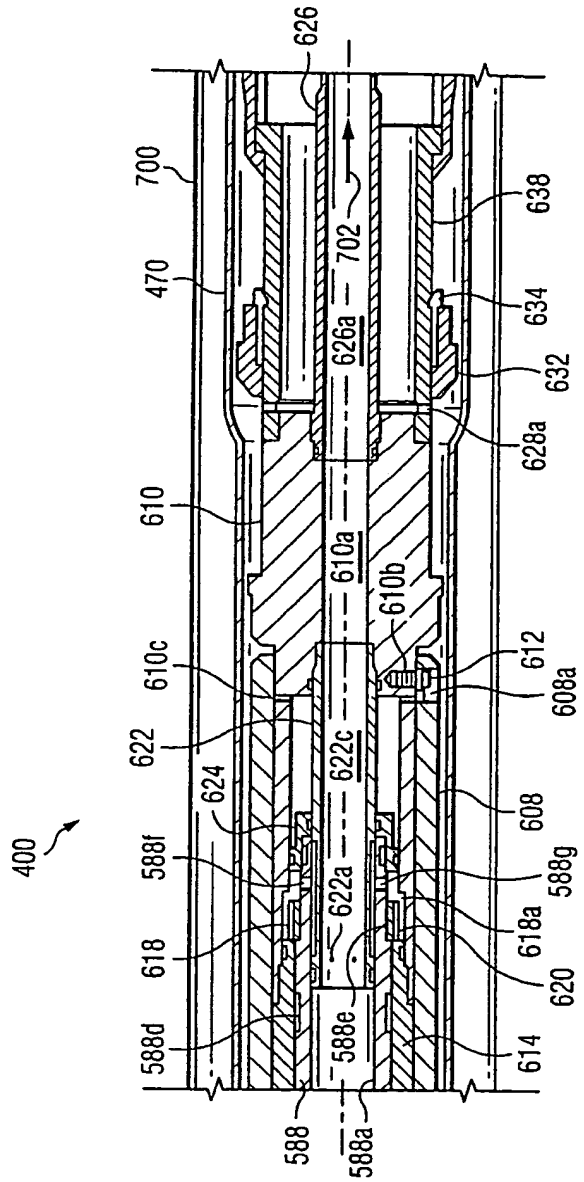


Fig. 311

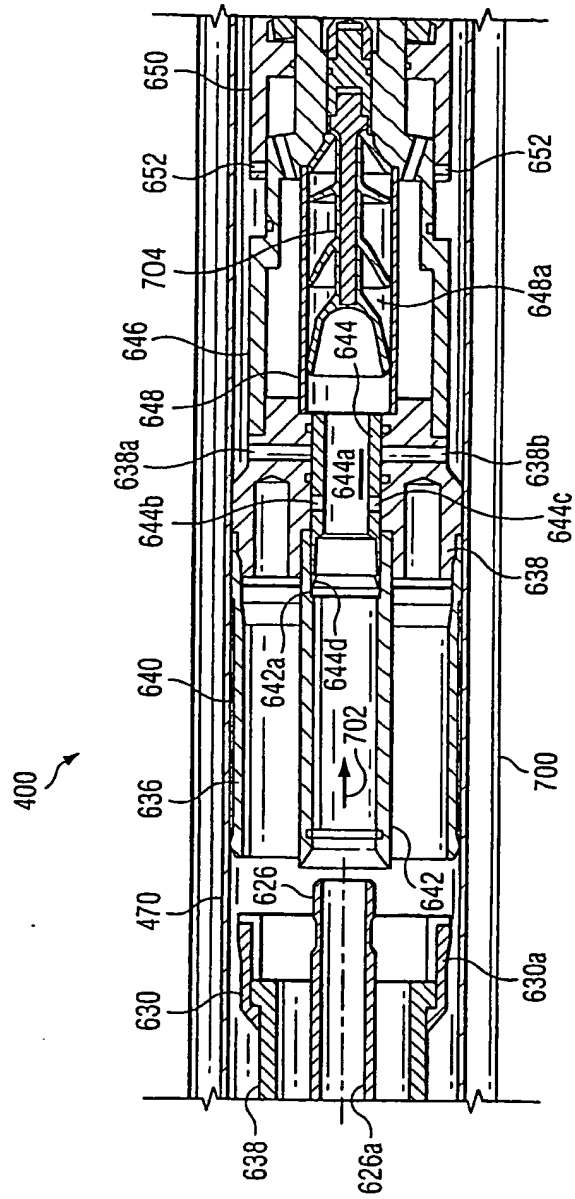
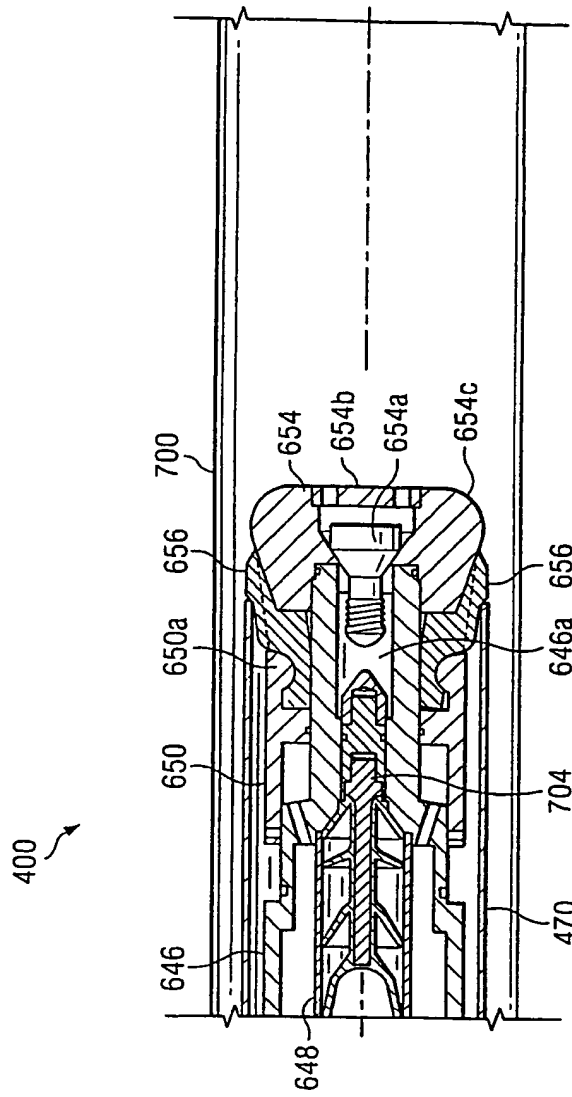


Fig. 31m





*Fig. 31n*

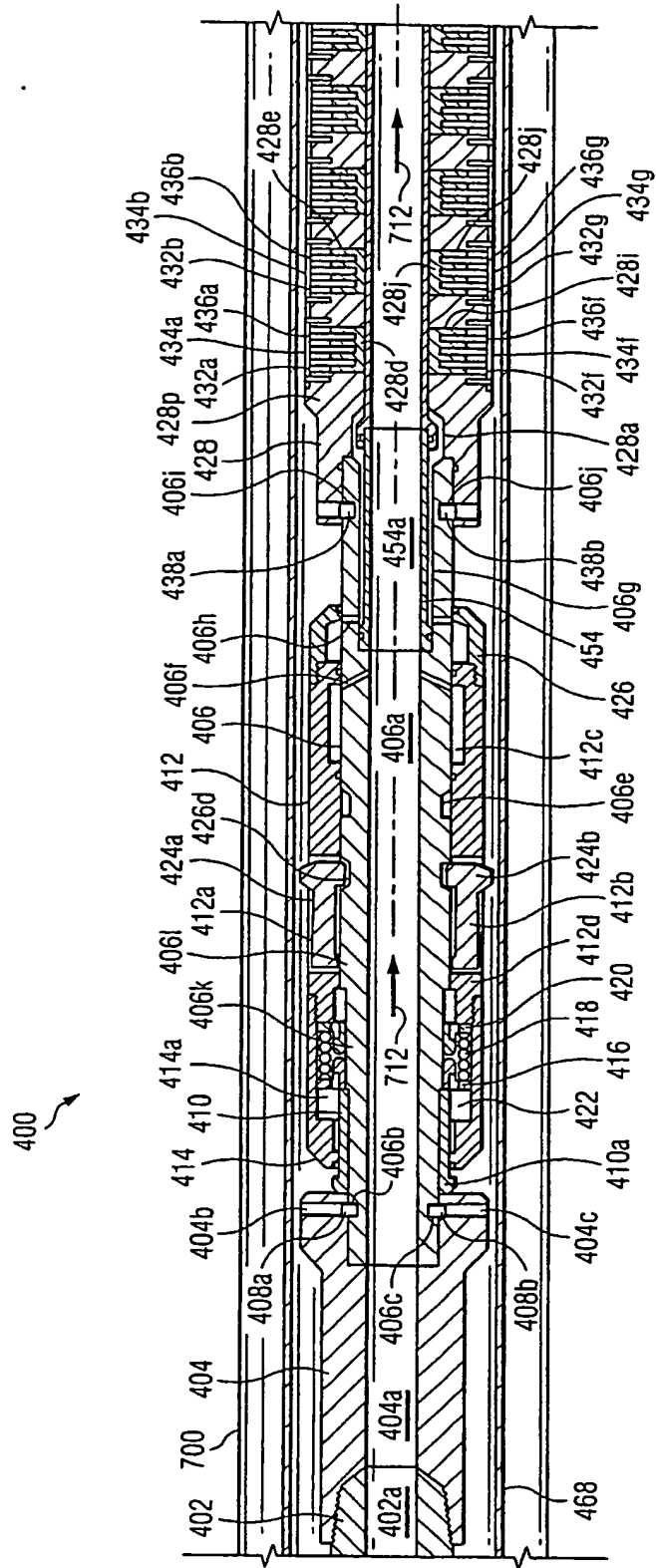


Fig. 32a

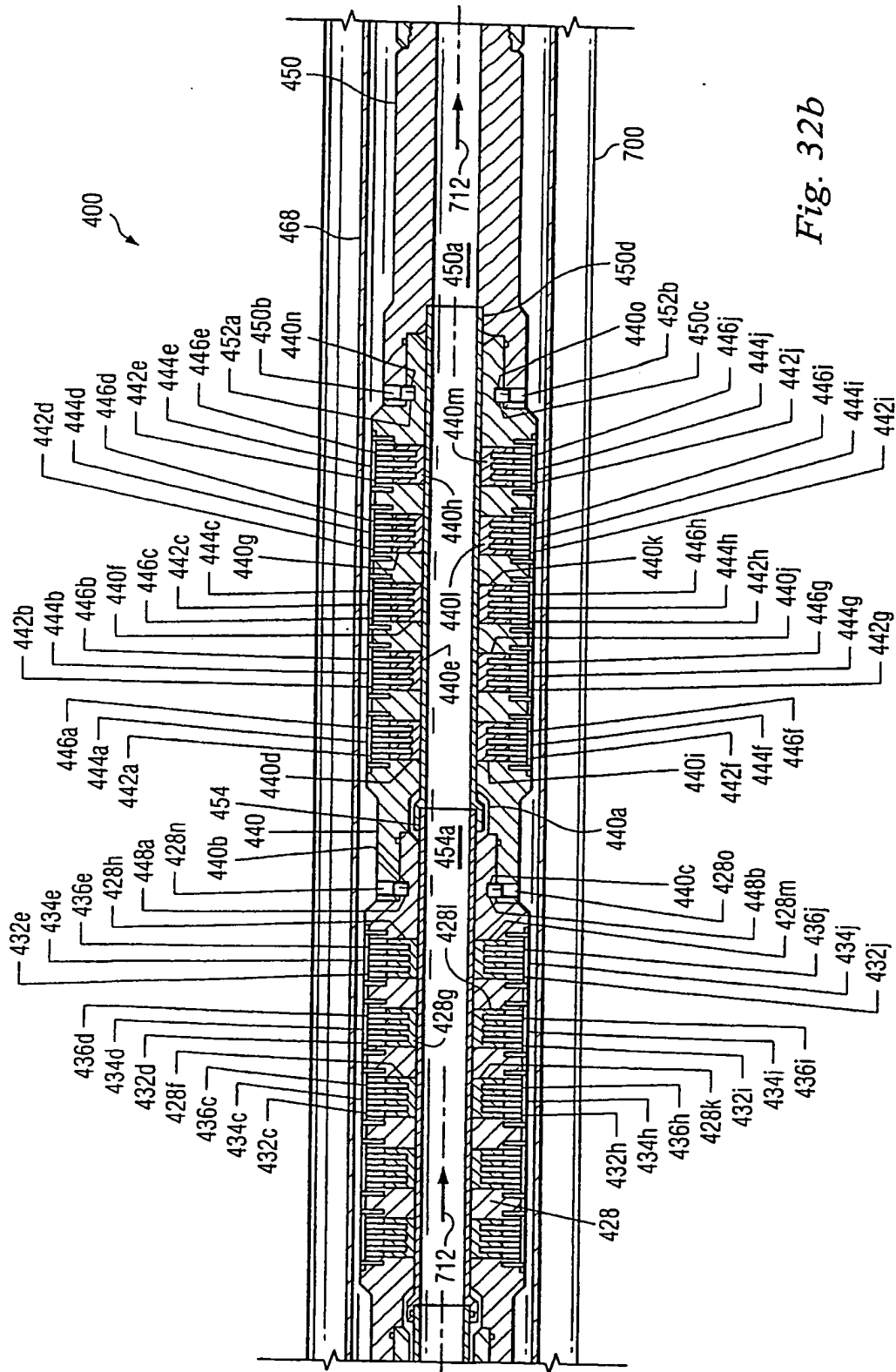


Fig. 32b

400 ↗

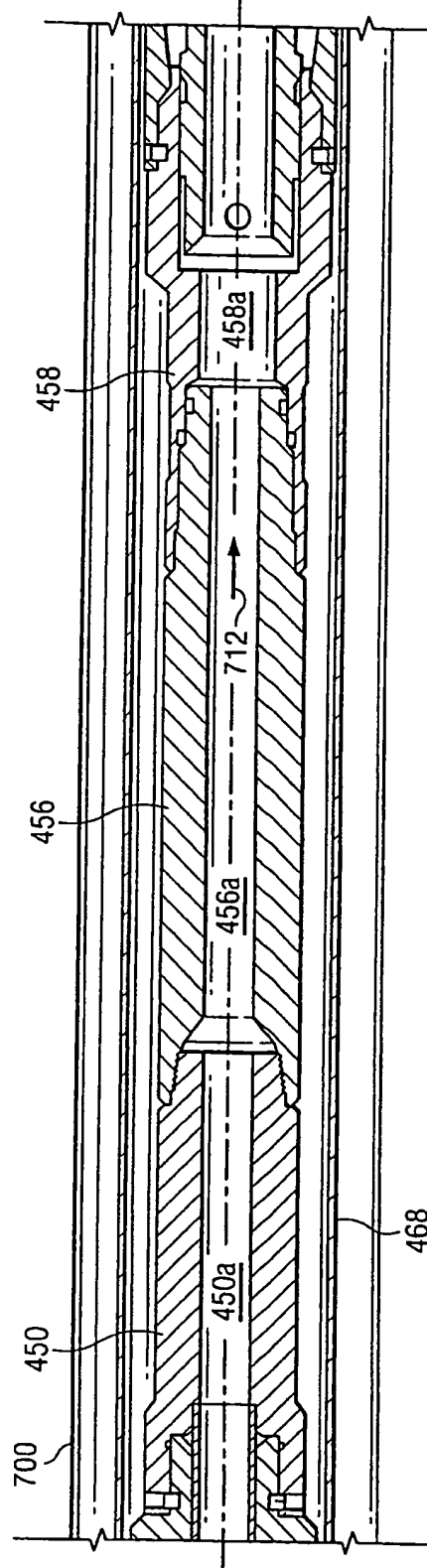


Fig. 32c

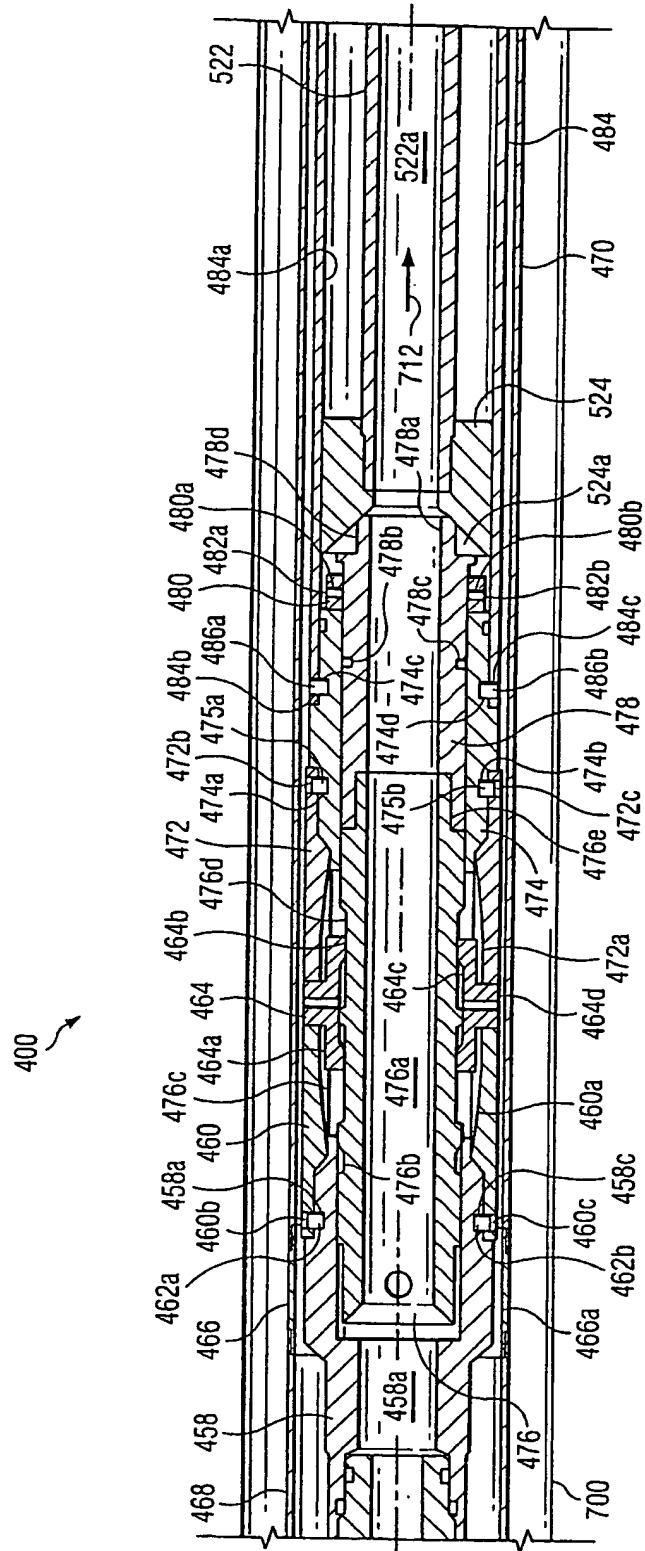


FIG. 32d

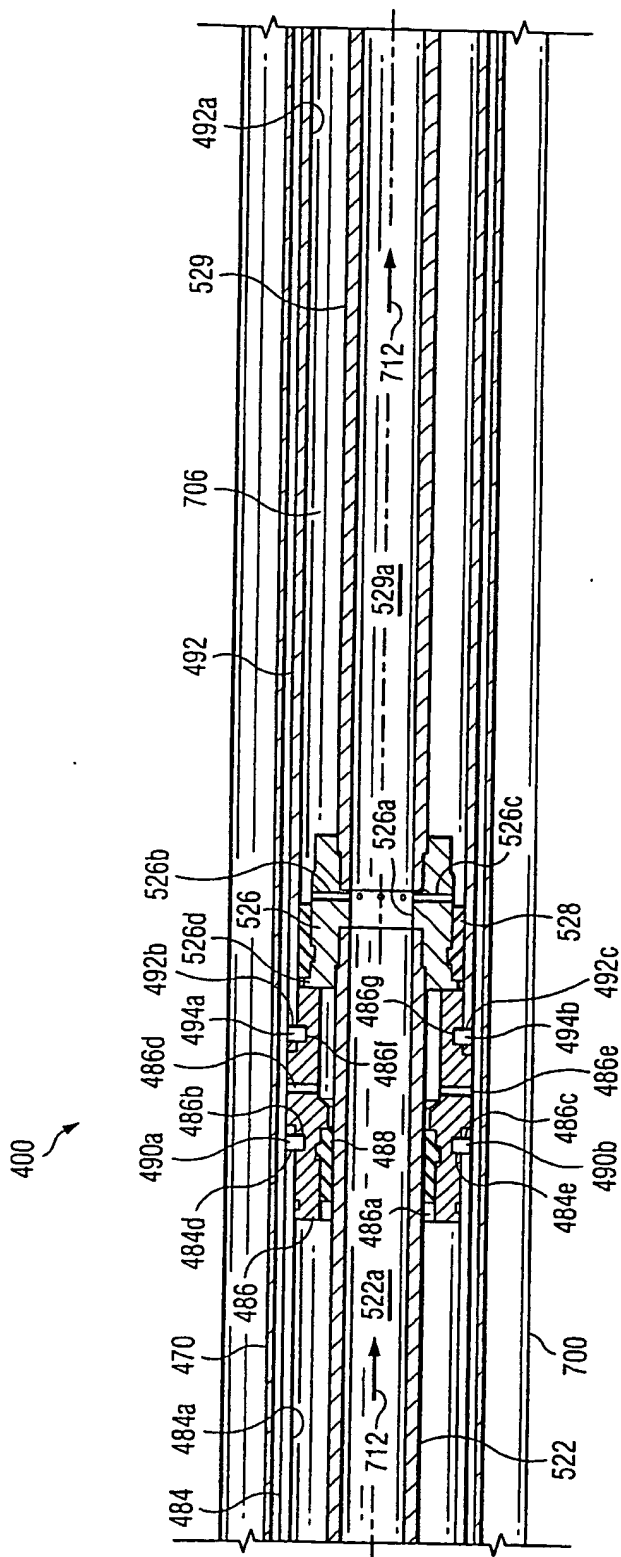


Fig. 32e

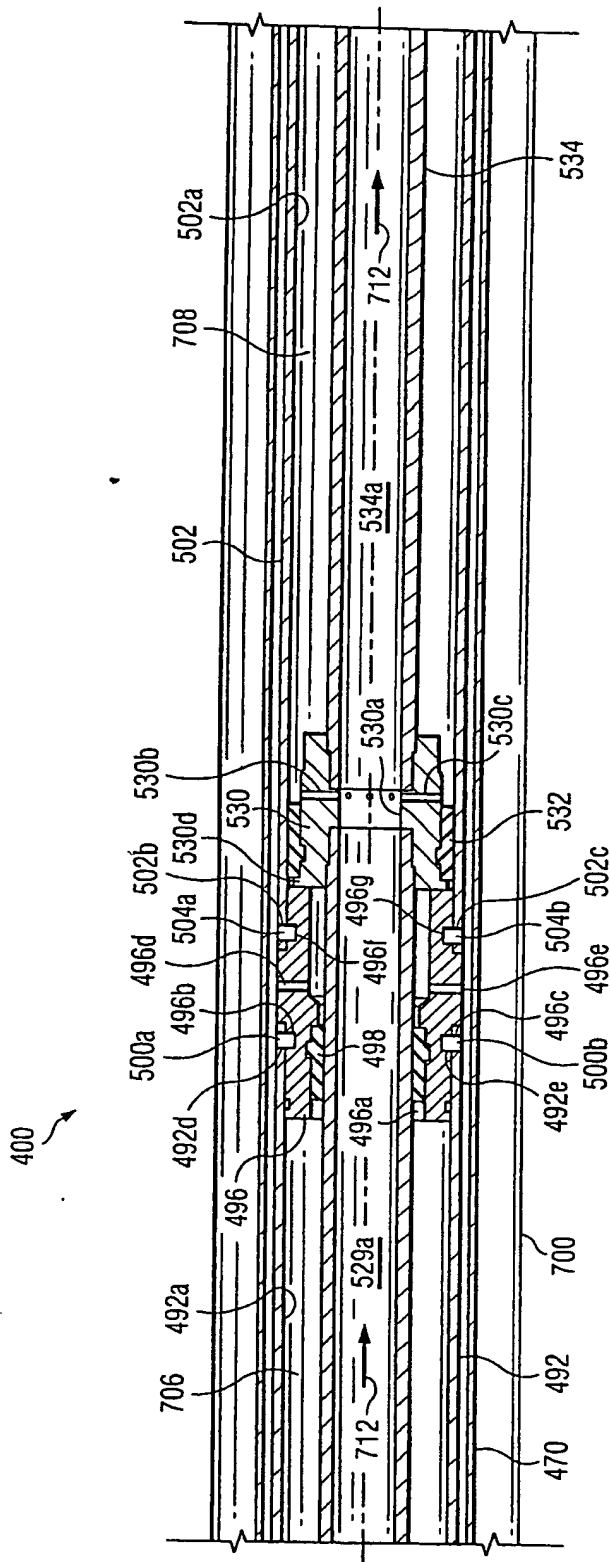


Fig. 32f

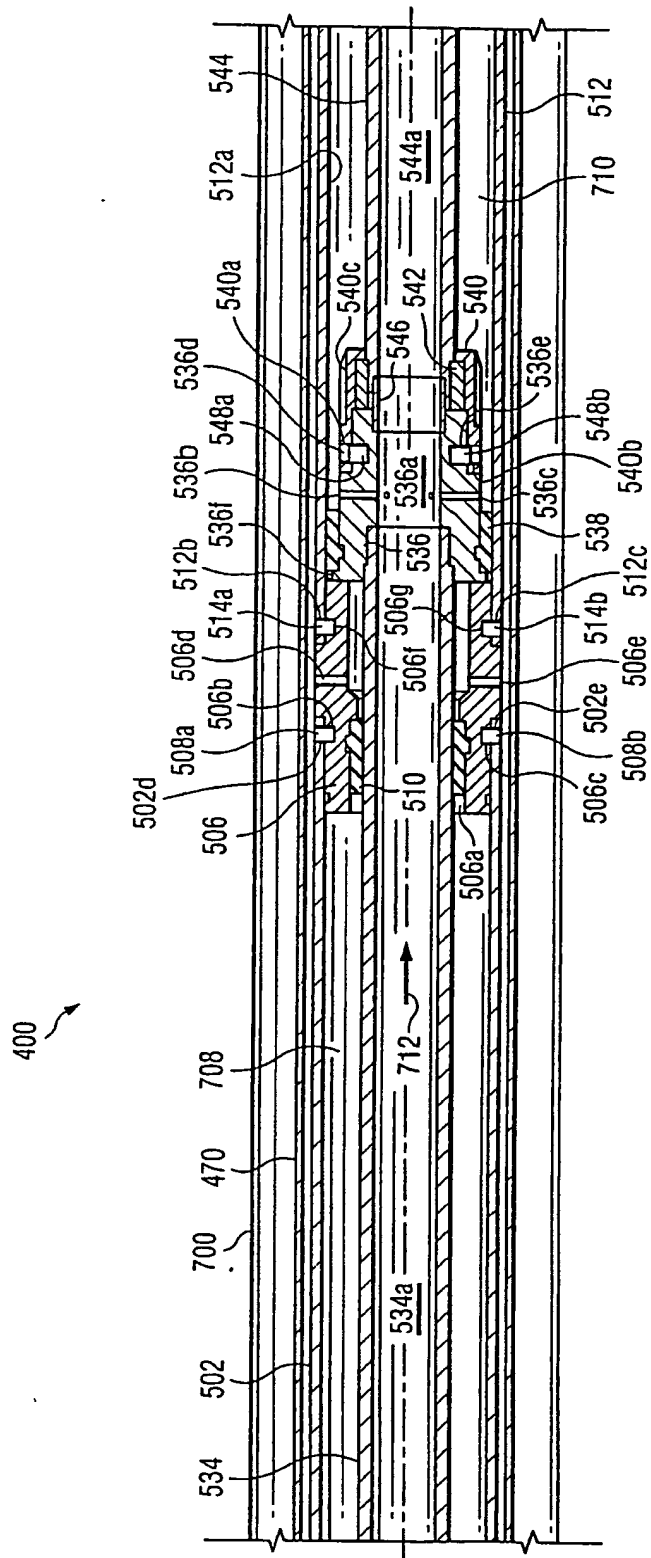


Fig. 32g



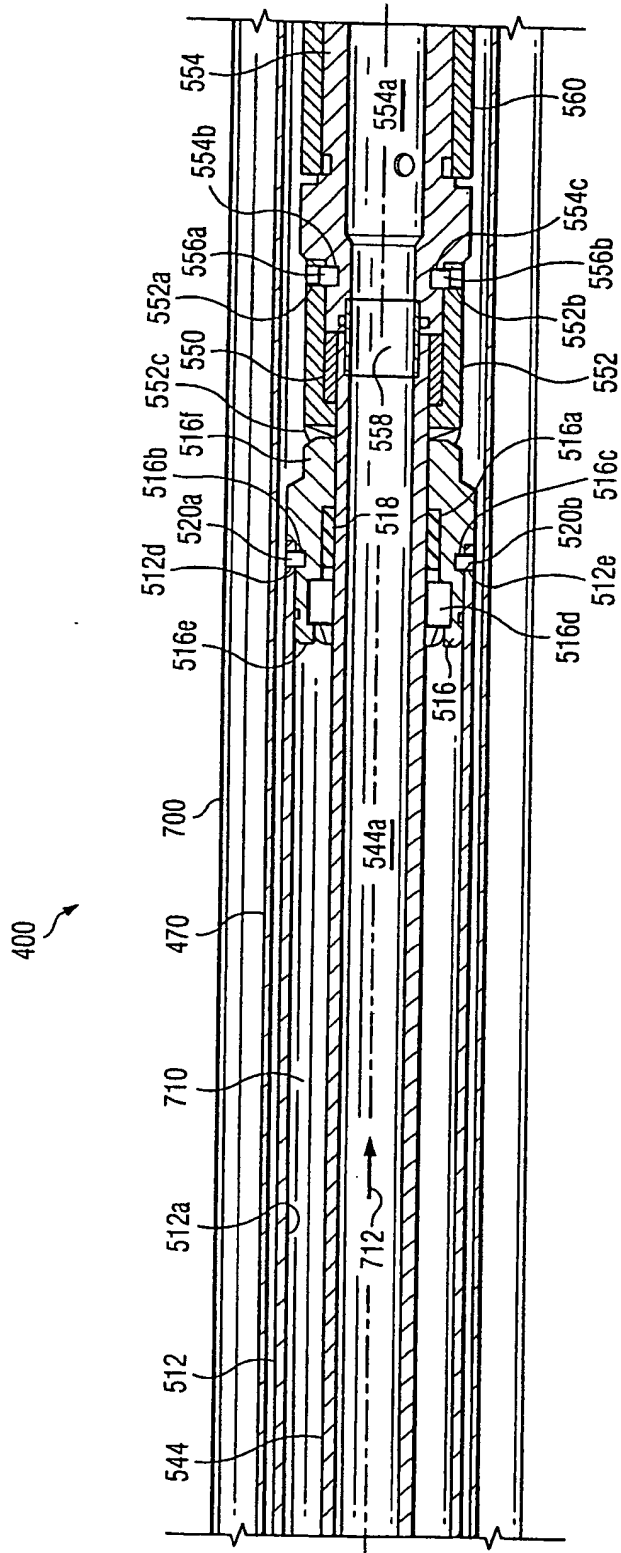


Fig. 32h

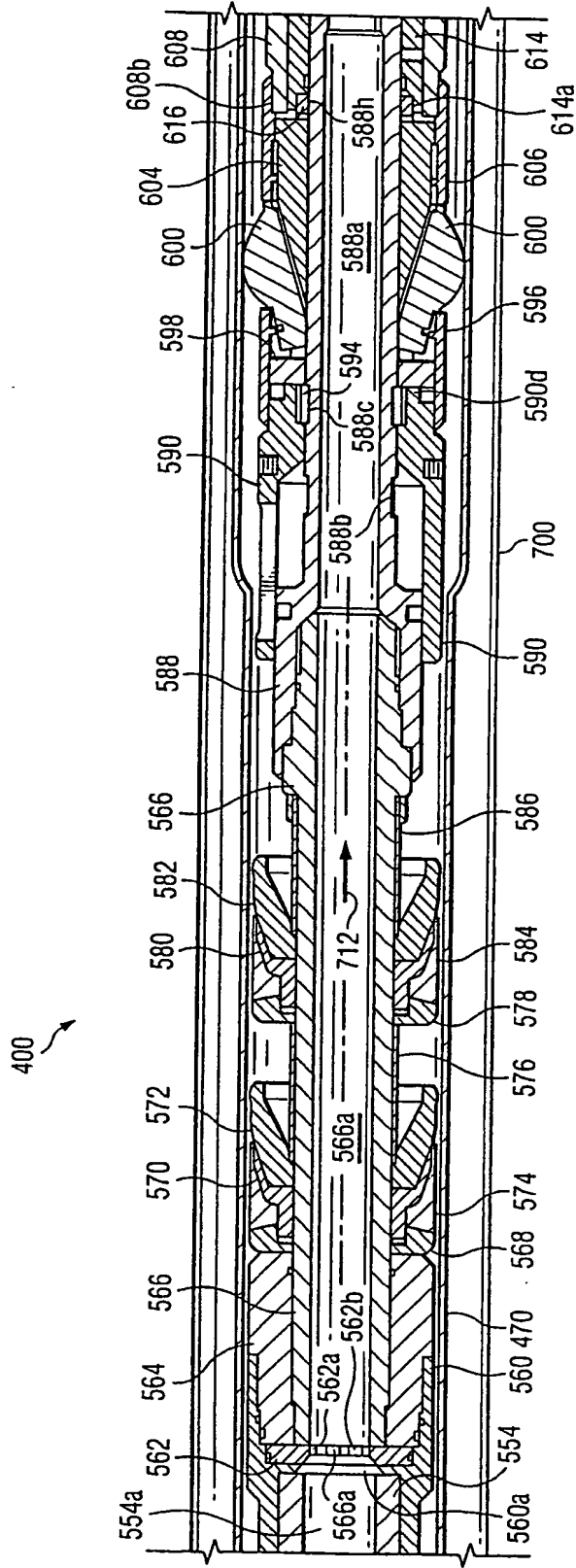


Fig. 32i

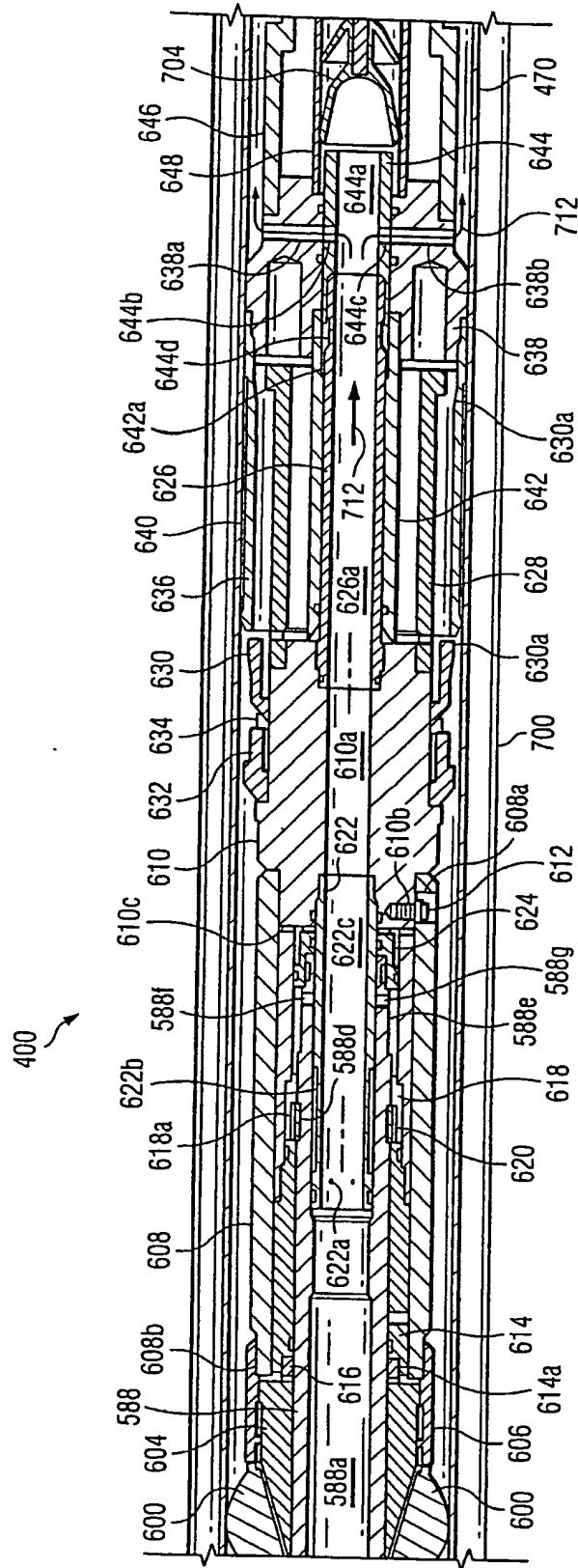


Fig. 32j

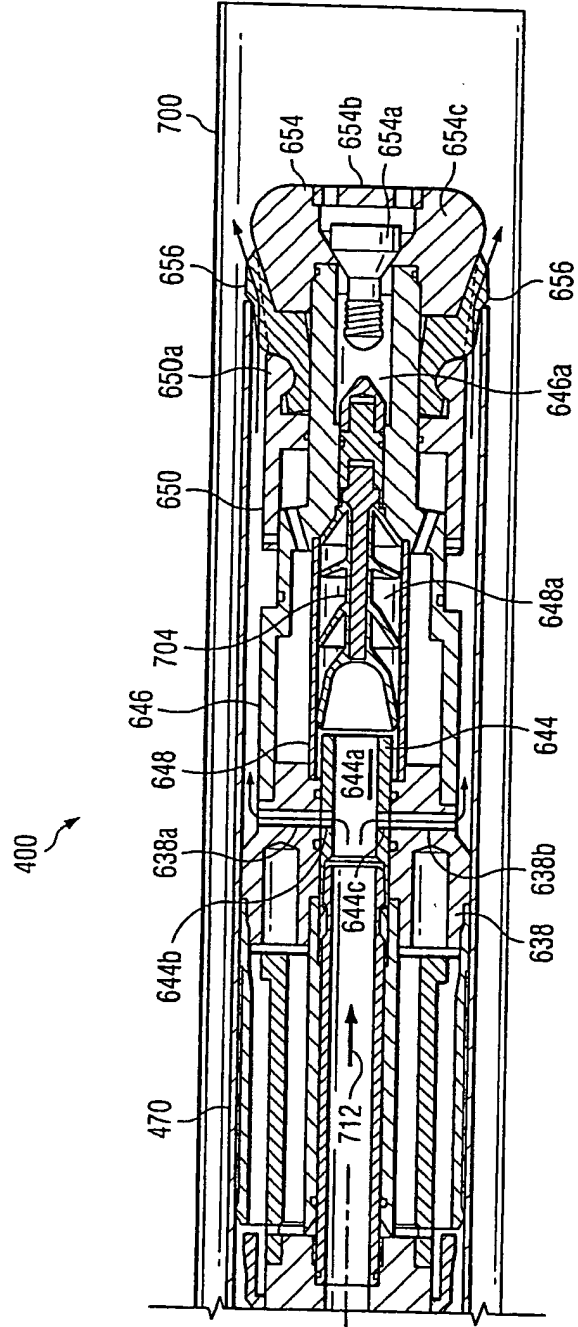


Fig. 32k

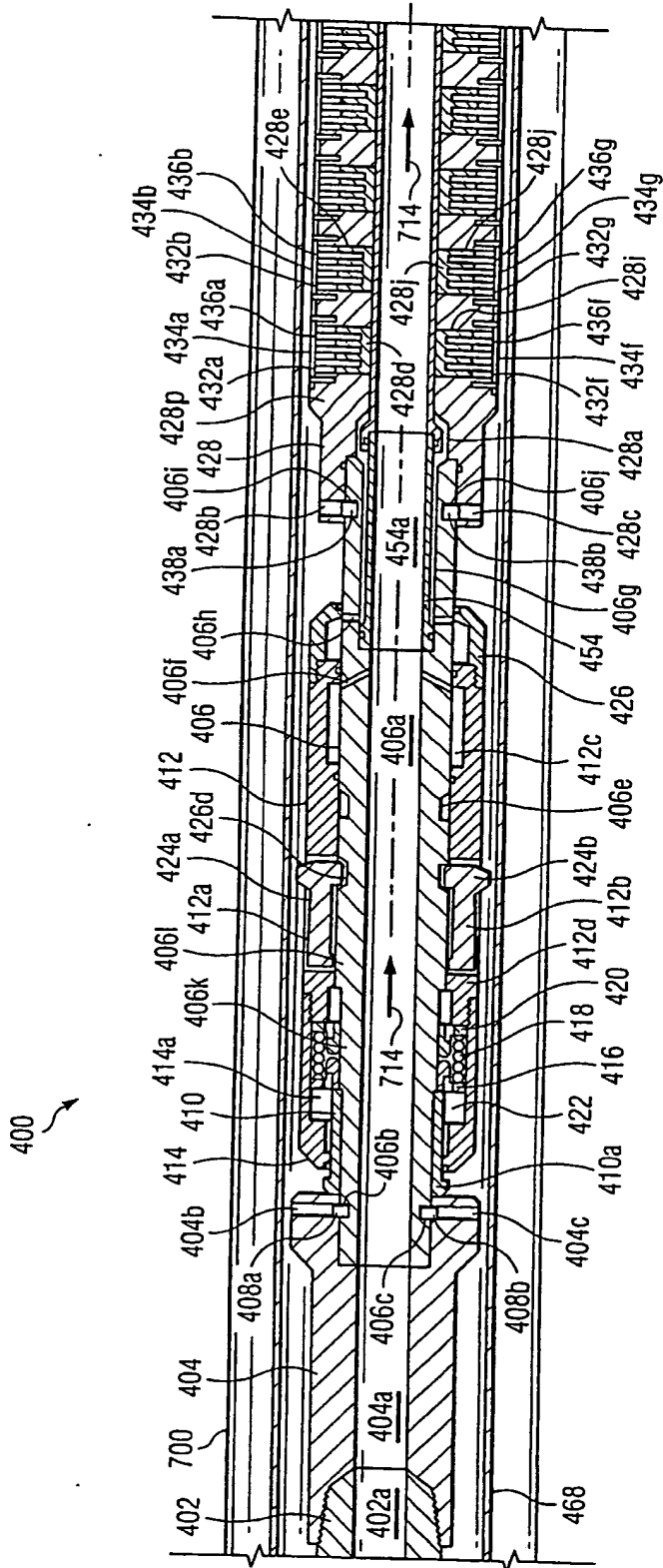
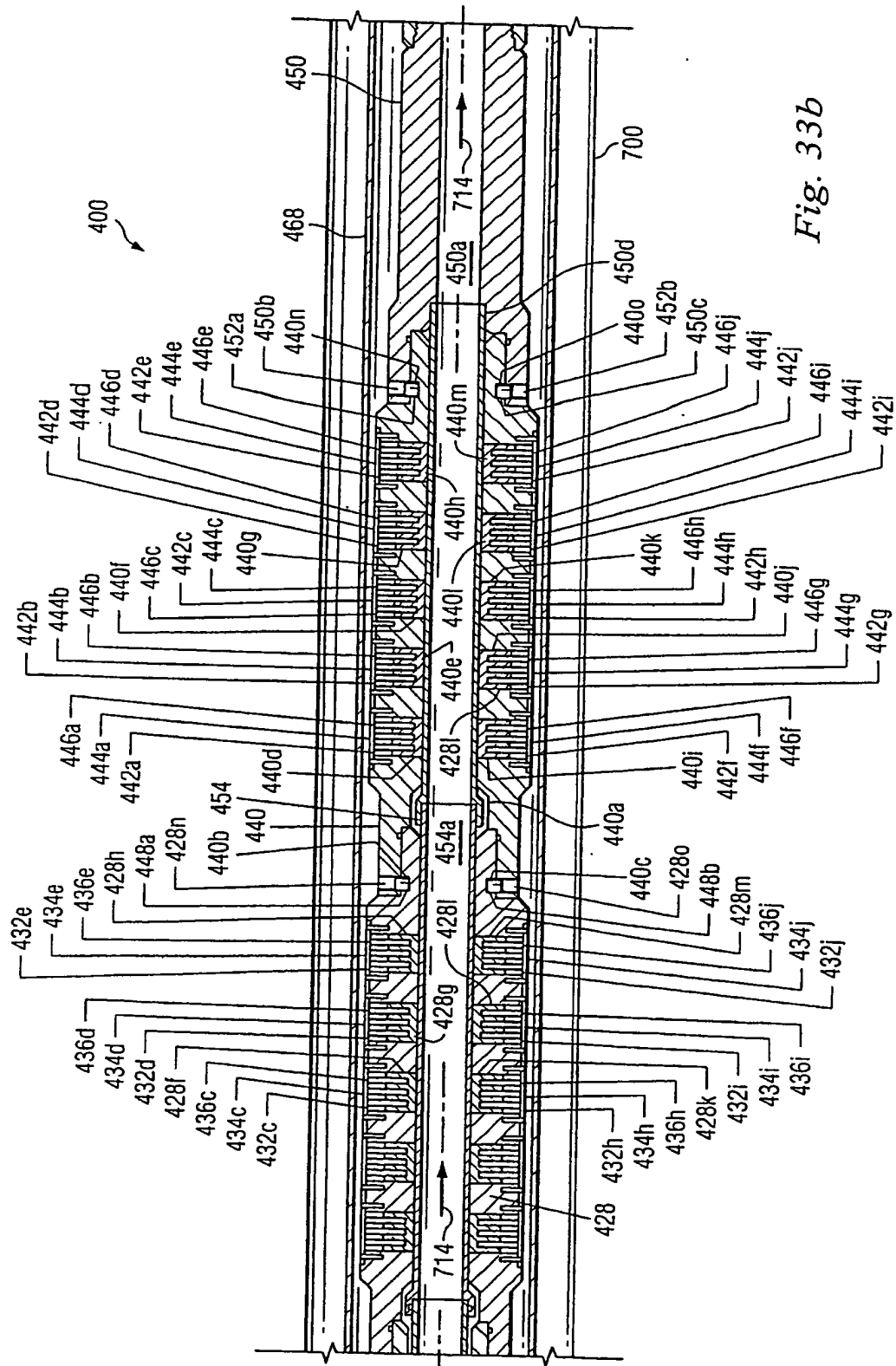


Fig. 33a



400

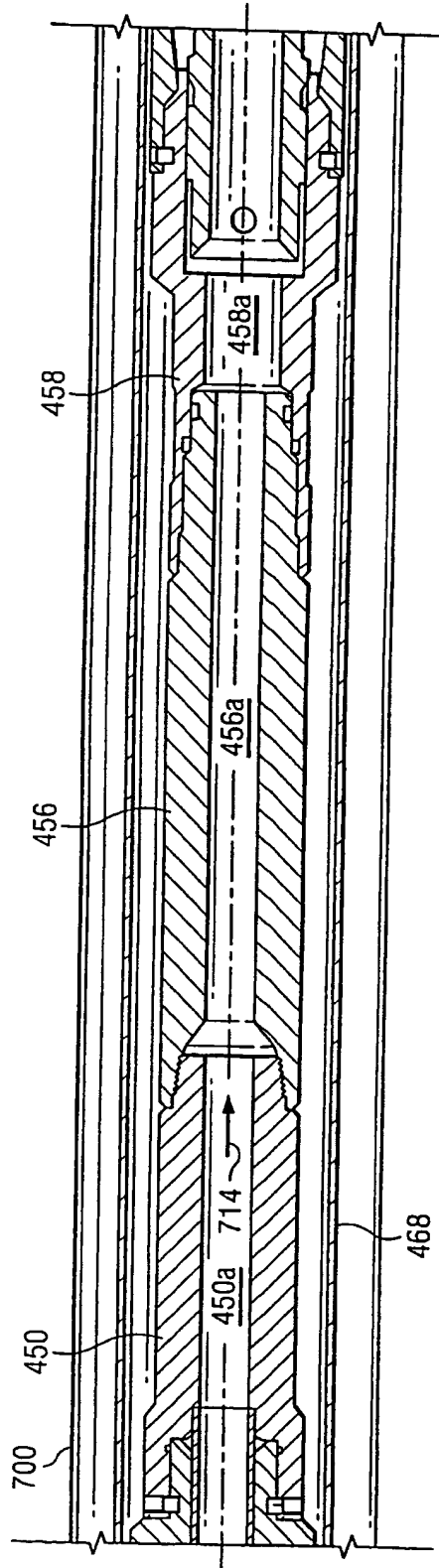


Fig. 33c



*Fig. 33d*



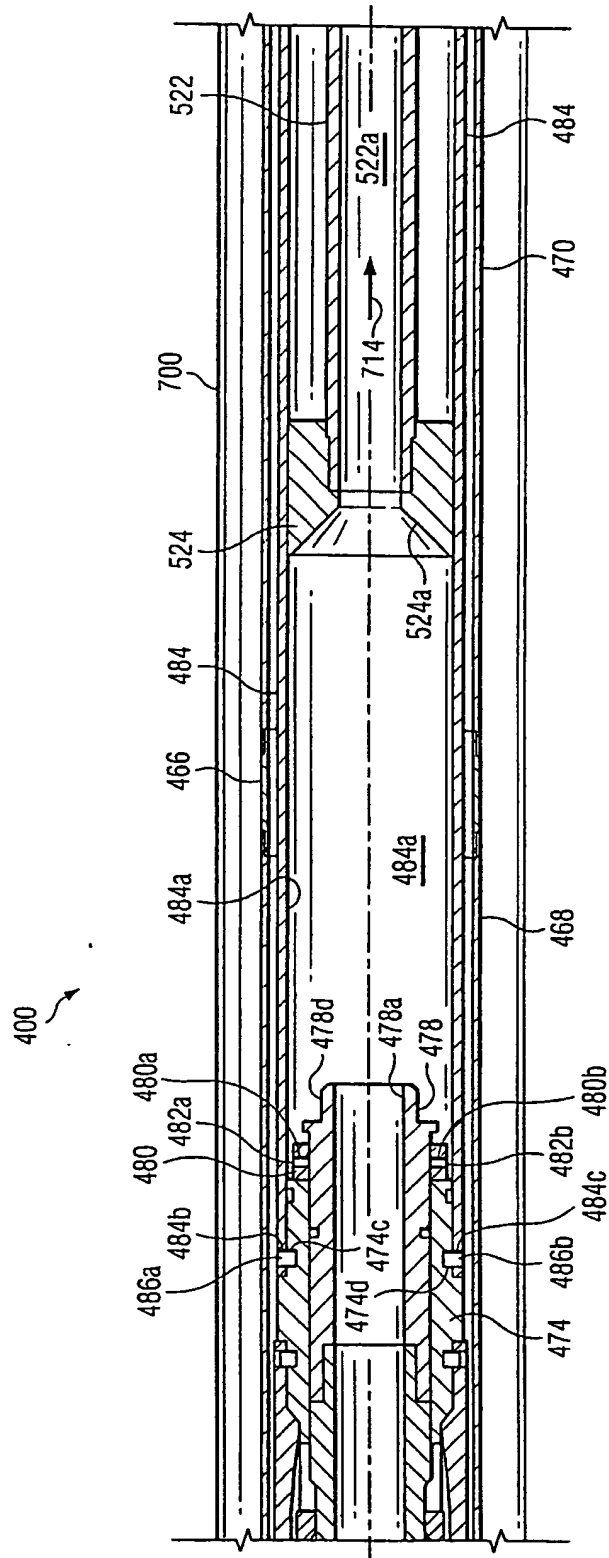


Fig. 33e

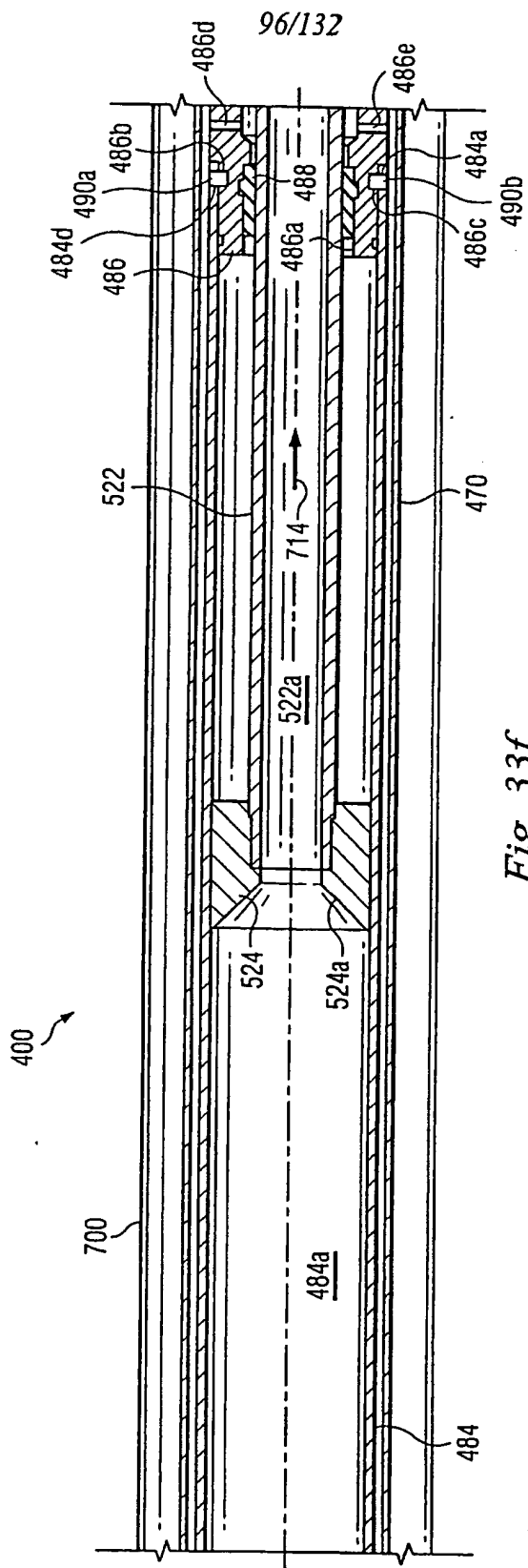


Fig. 33f

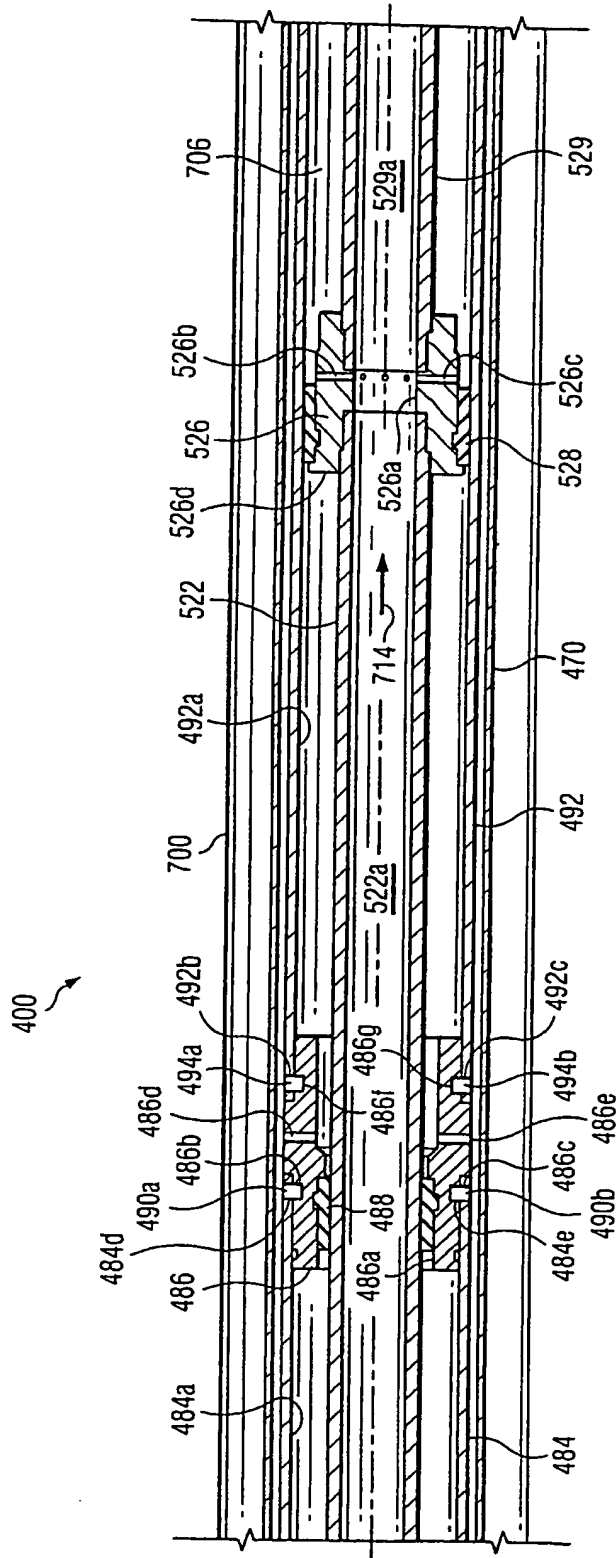


Fig. 33g

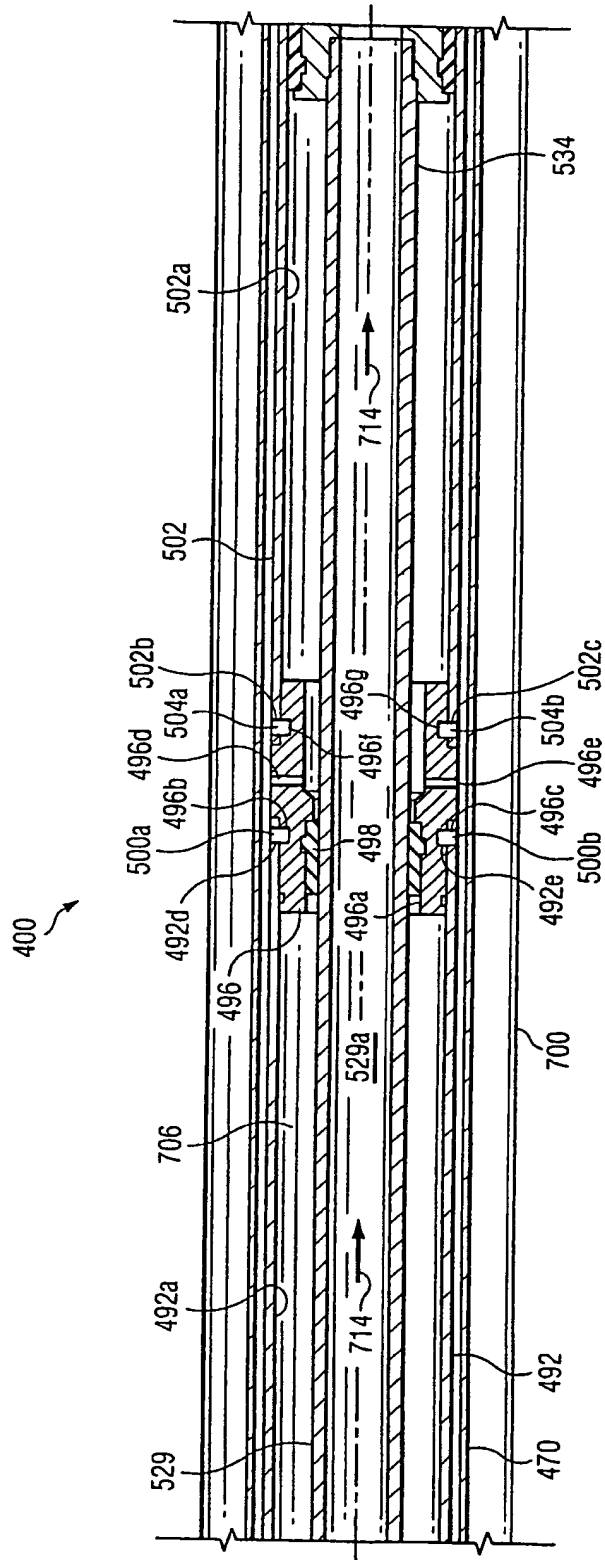


Fig. 33h

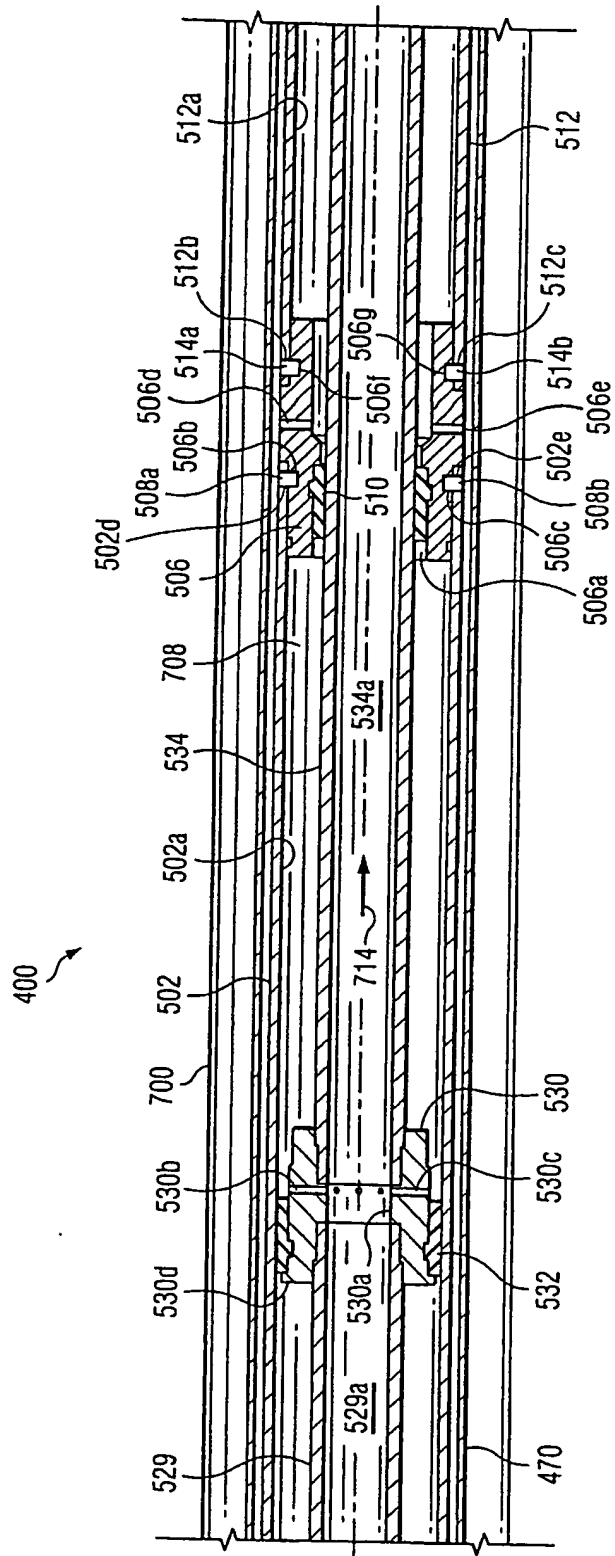


Fig. 33i

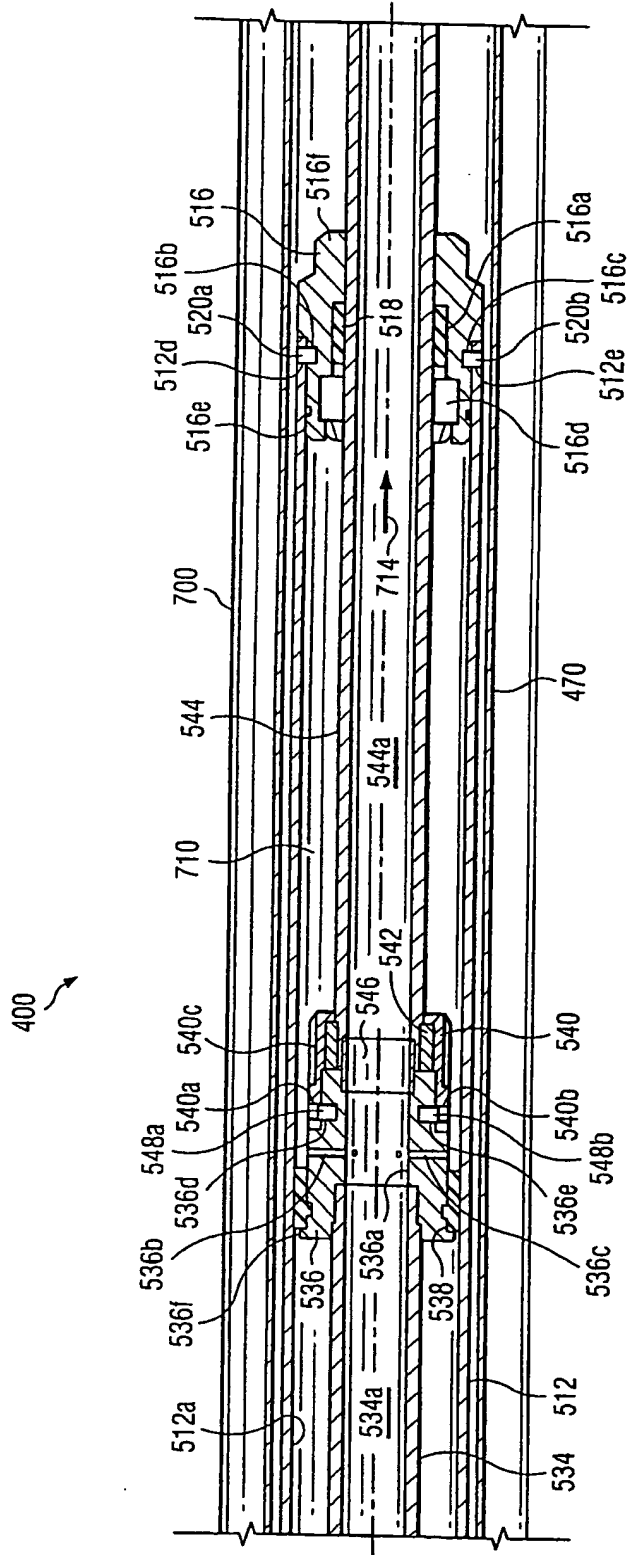


Fig. 33j

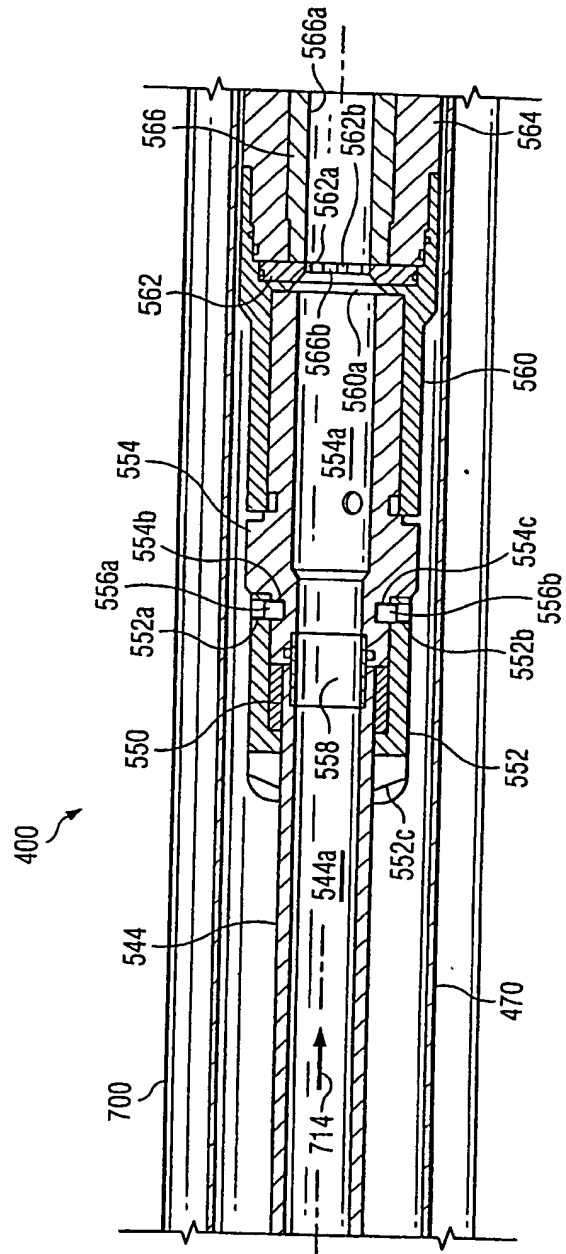


Fig. 33k

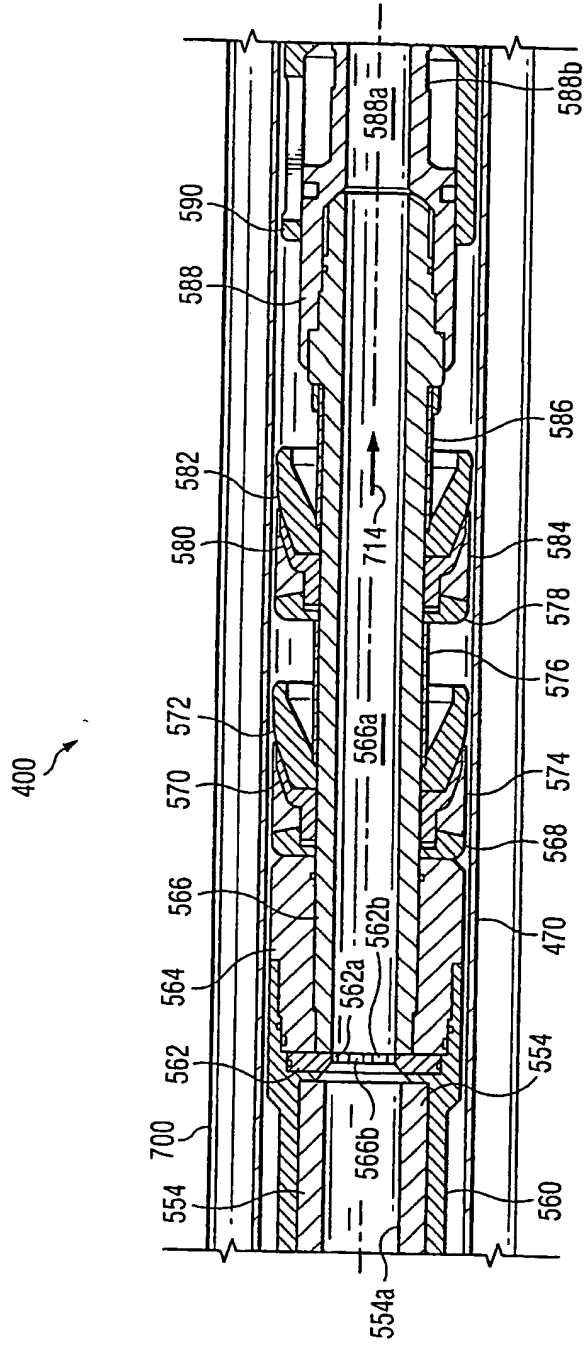


Fig. 331





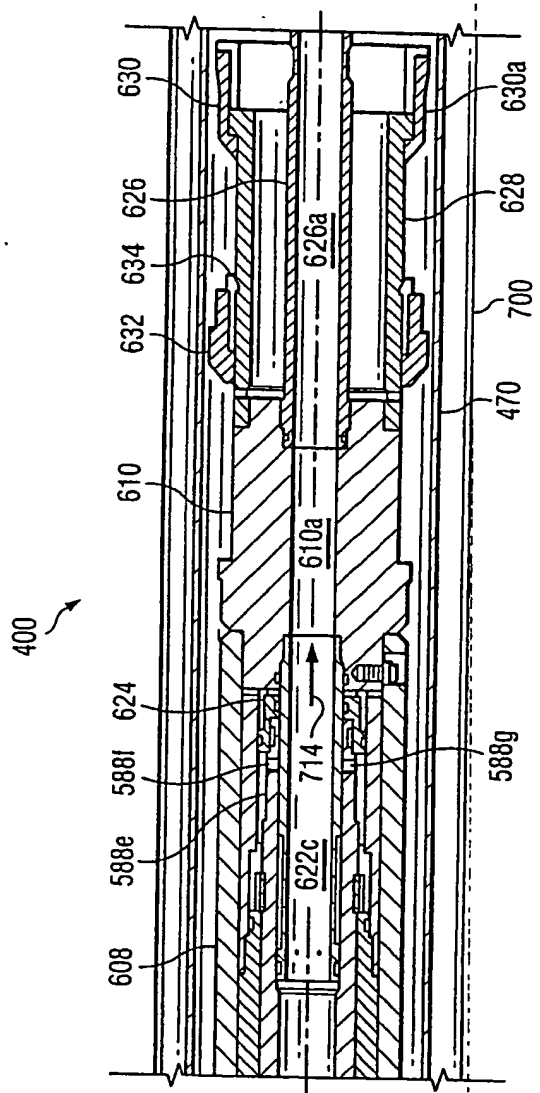


Fig. 33n

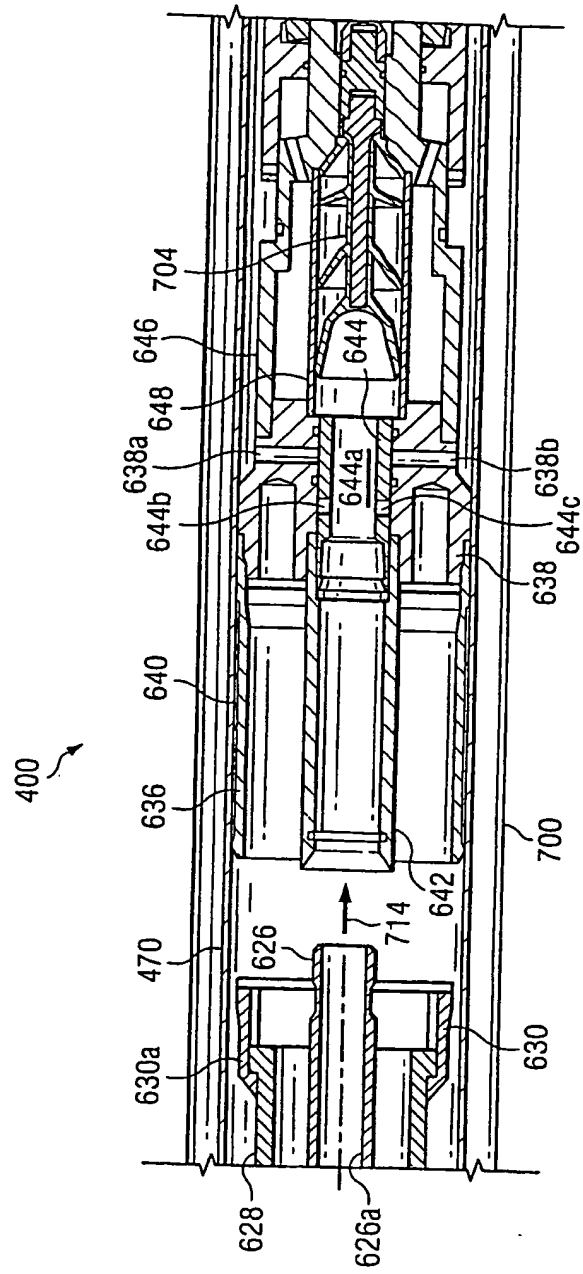


Fig. 330

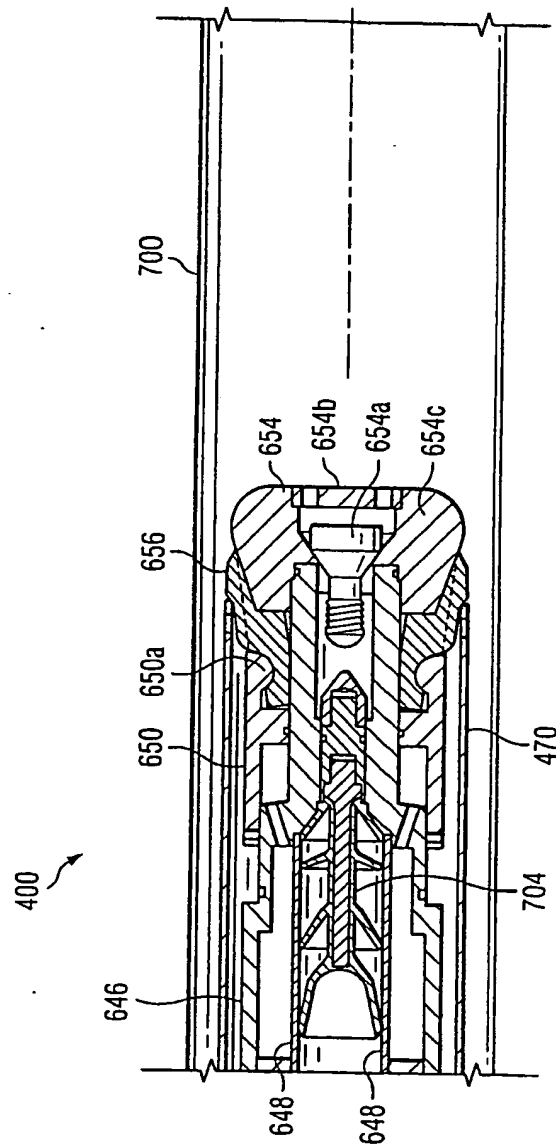


Fig. 33p

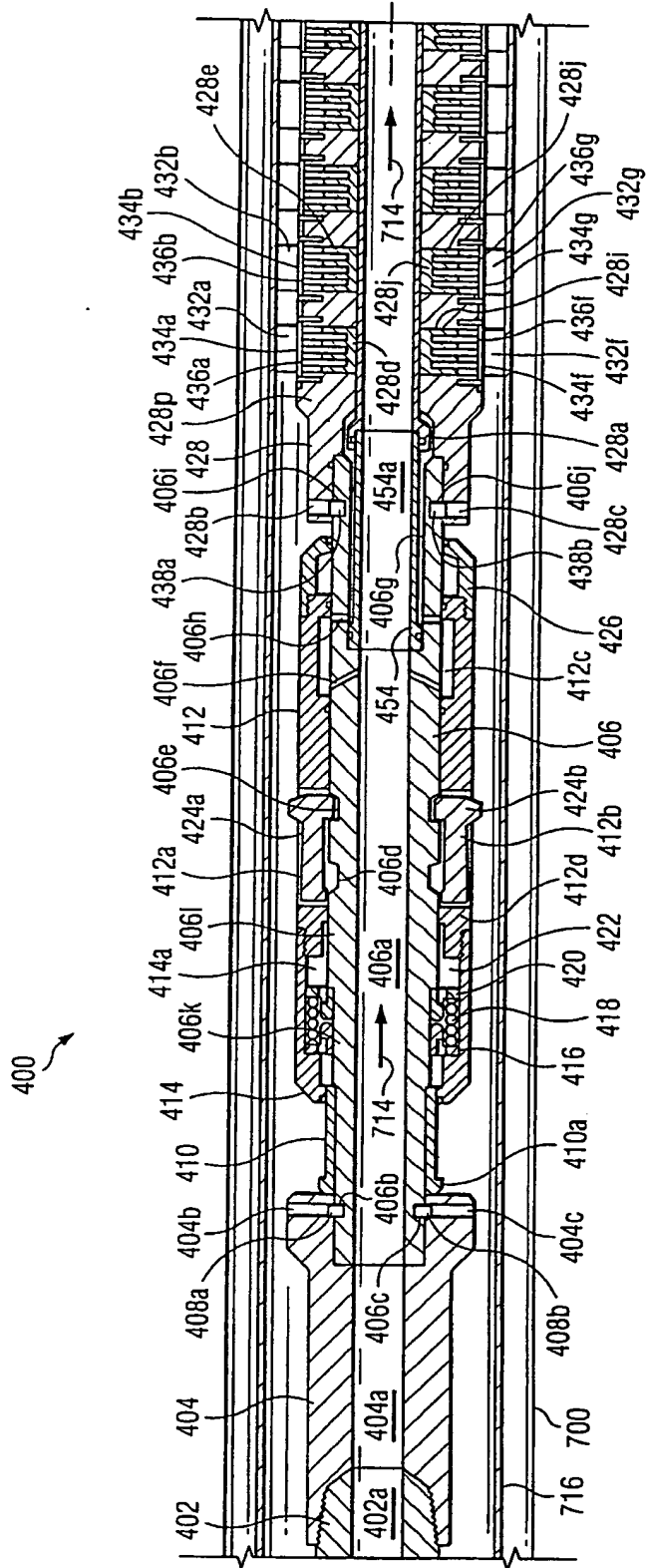


Fig. 34a

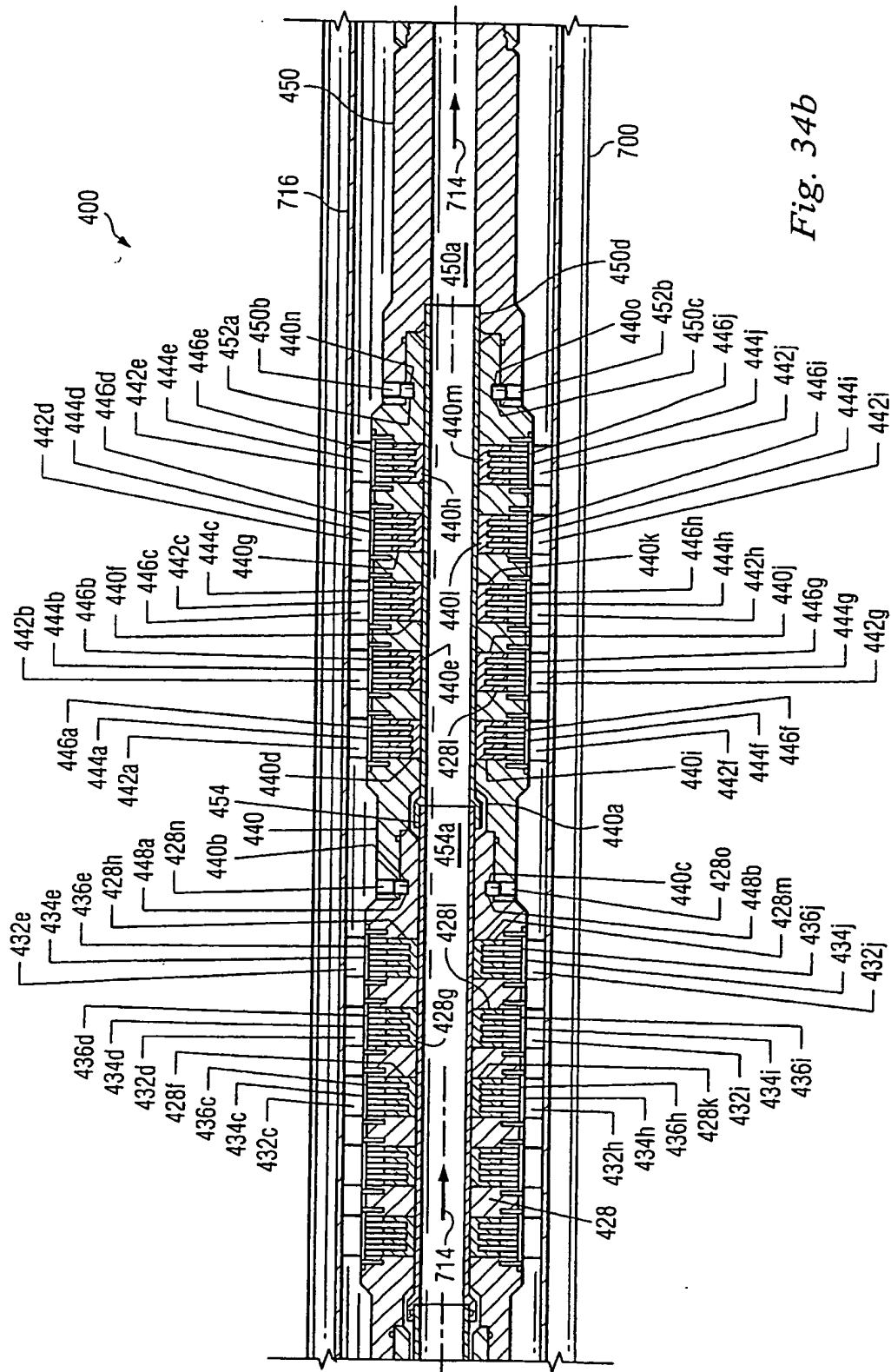


Fig. 34b

400 ↗

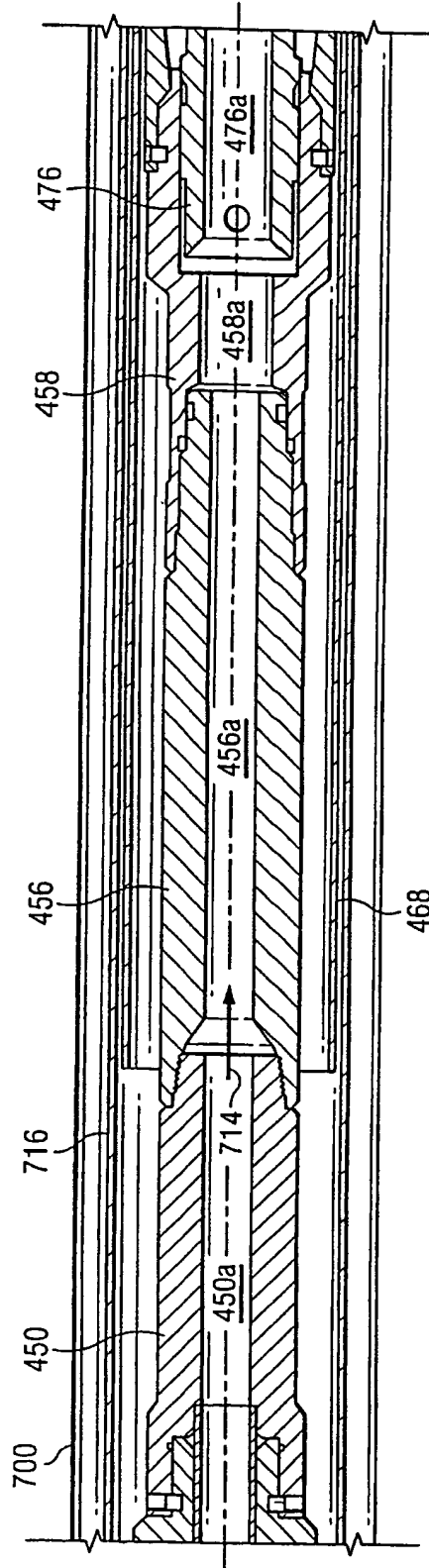


Fig. 34c

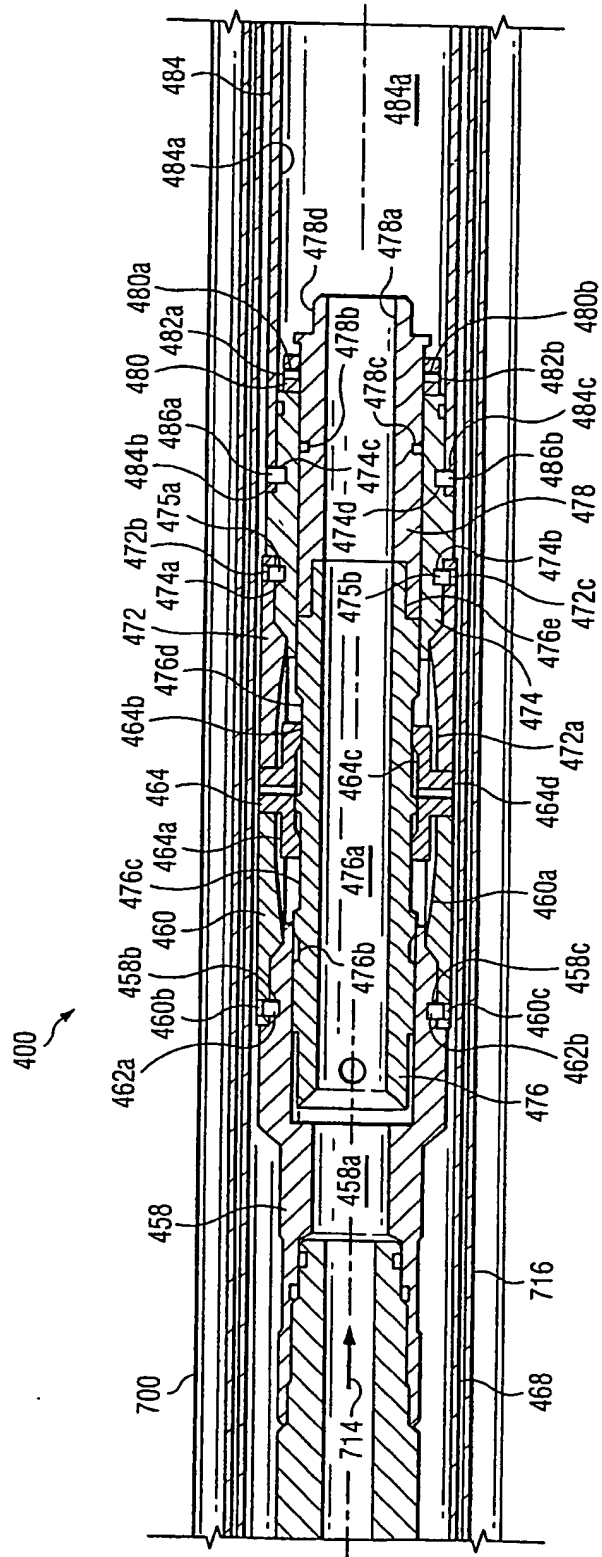


Fig. 34d



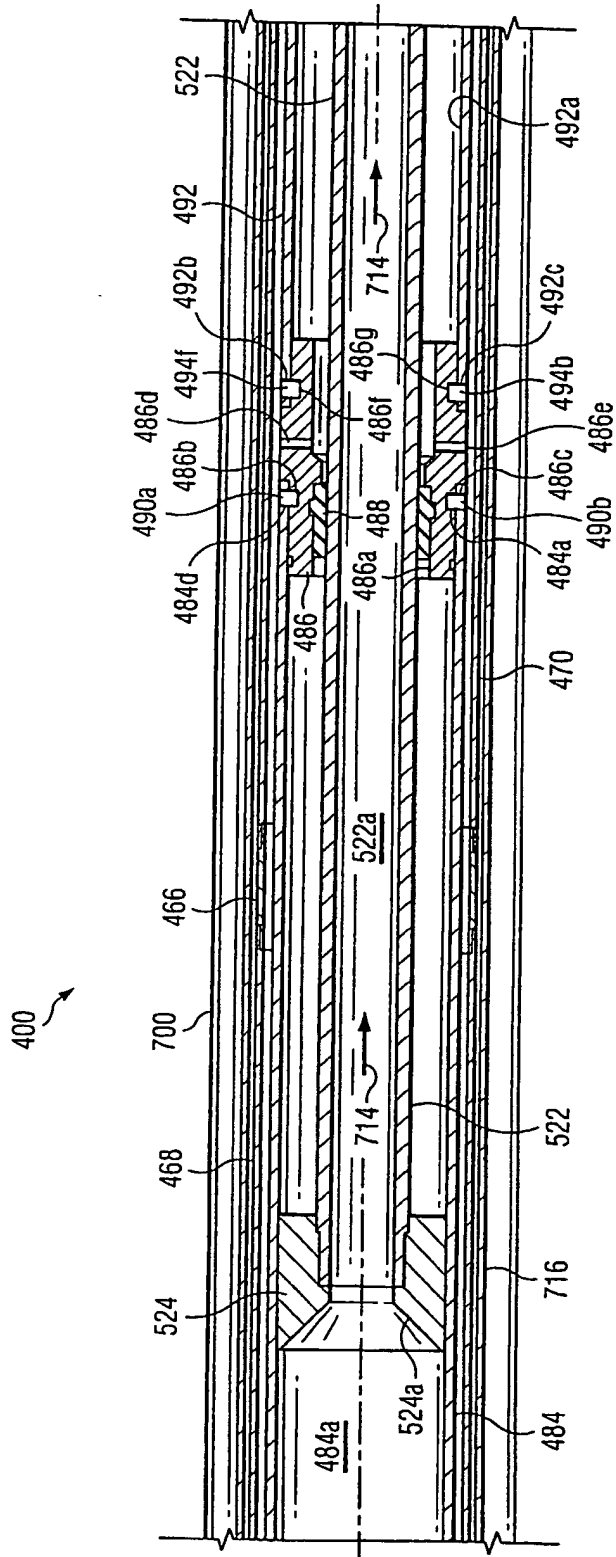


Fig. 34e

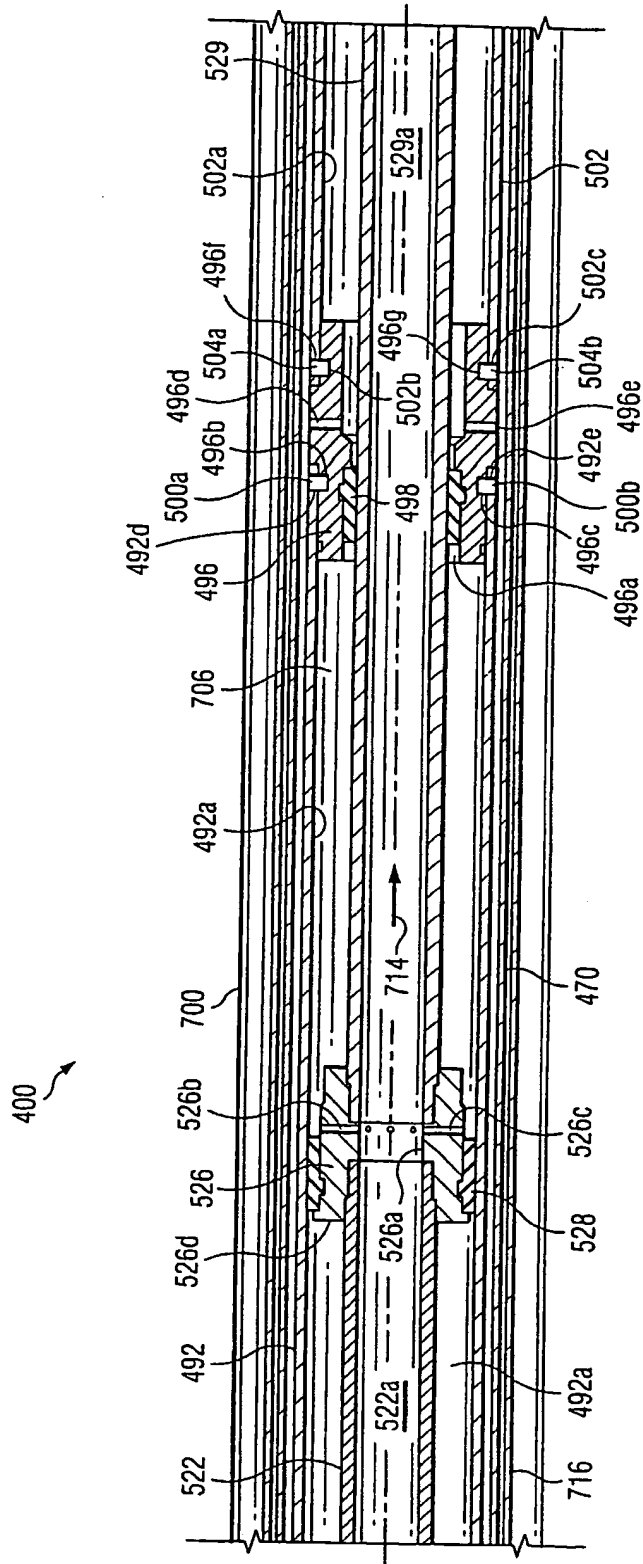


Fig. 34f

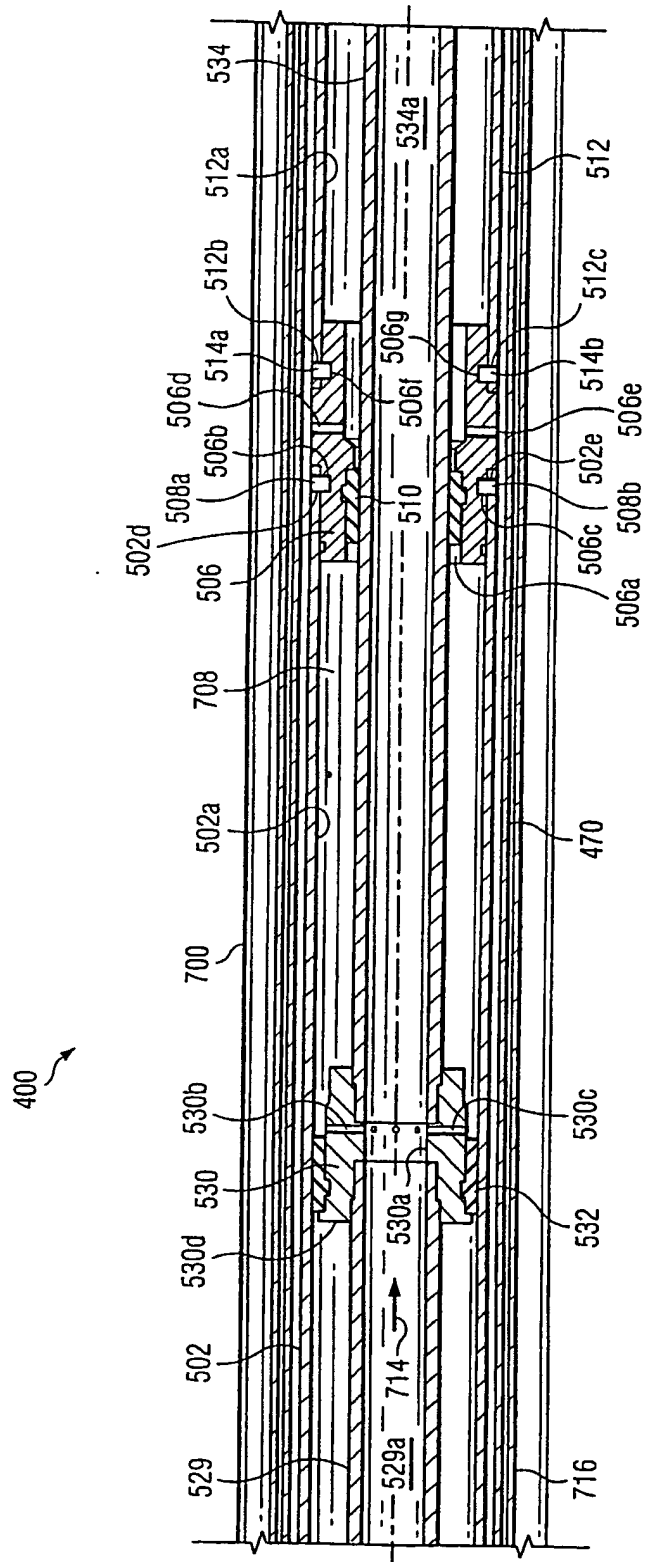


Fig. 34g

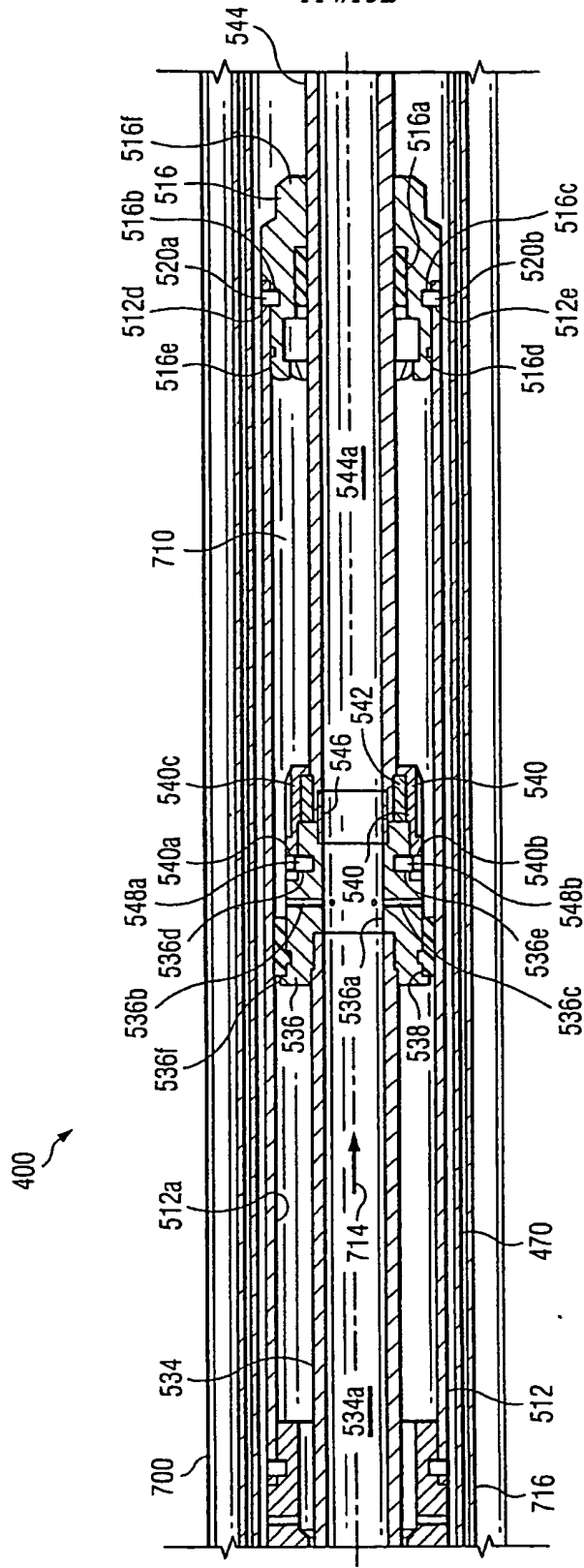


Fig. 34h

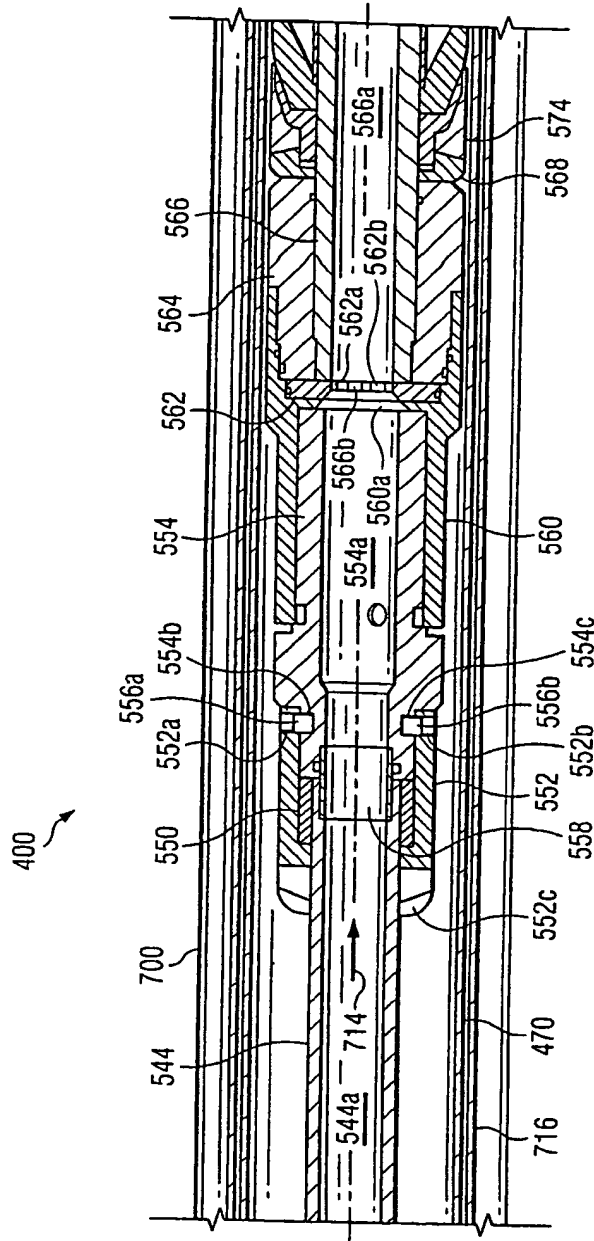


Fig. 34i

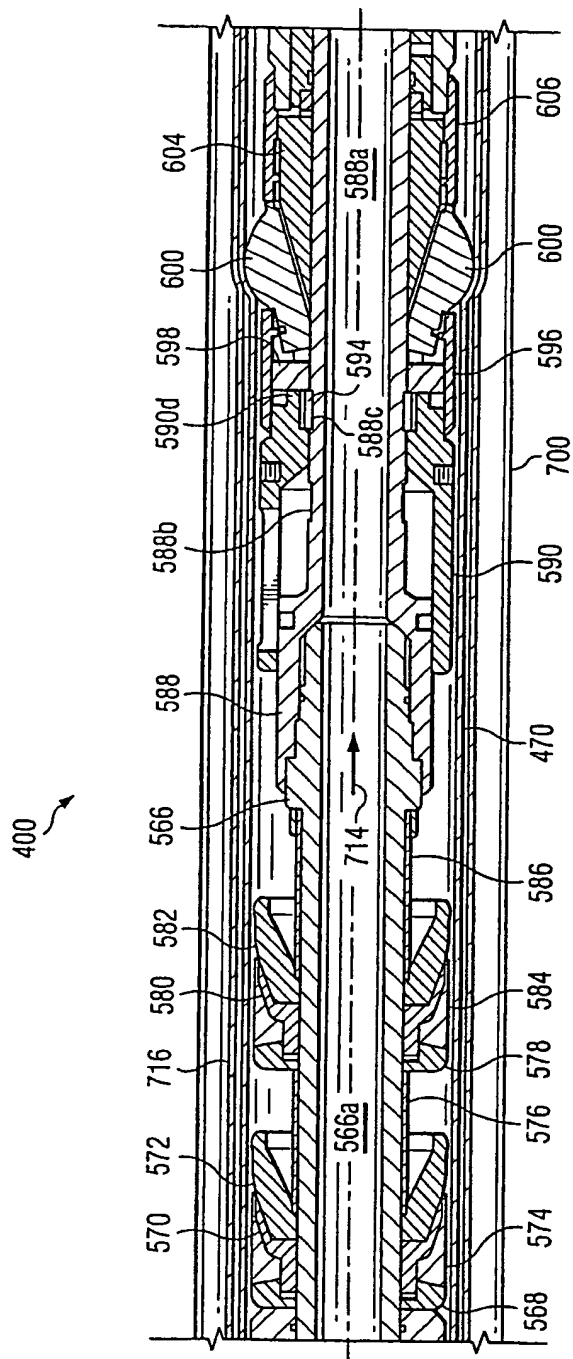


Fig. 34j

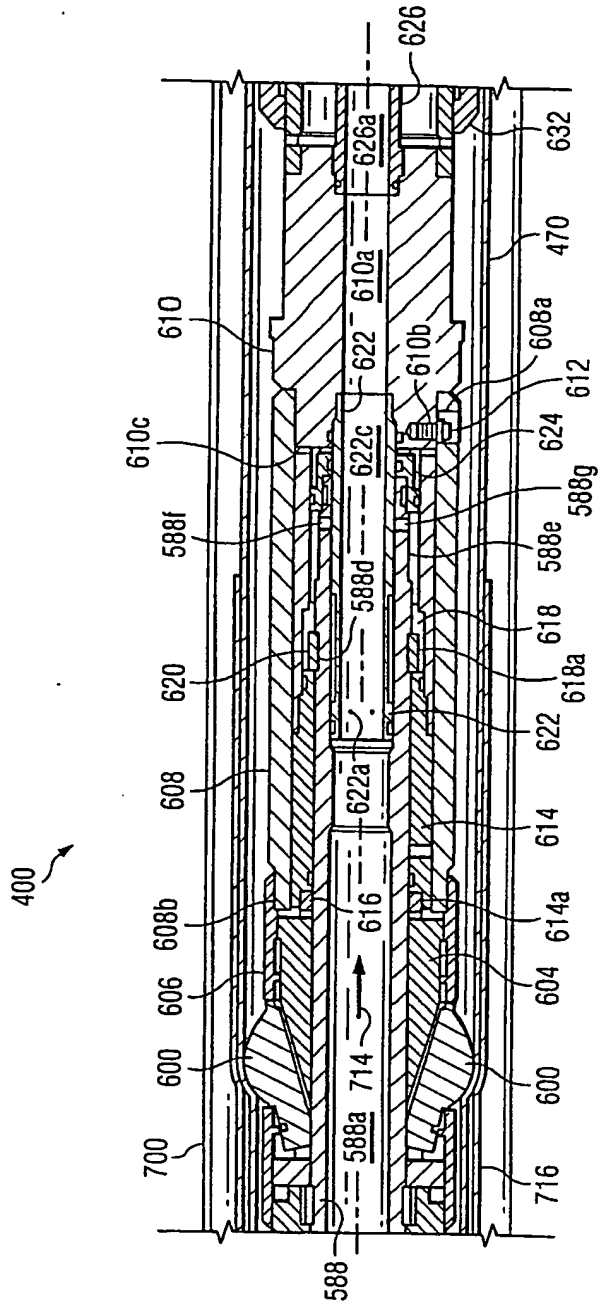


Fig. 34k

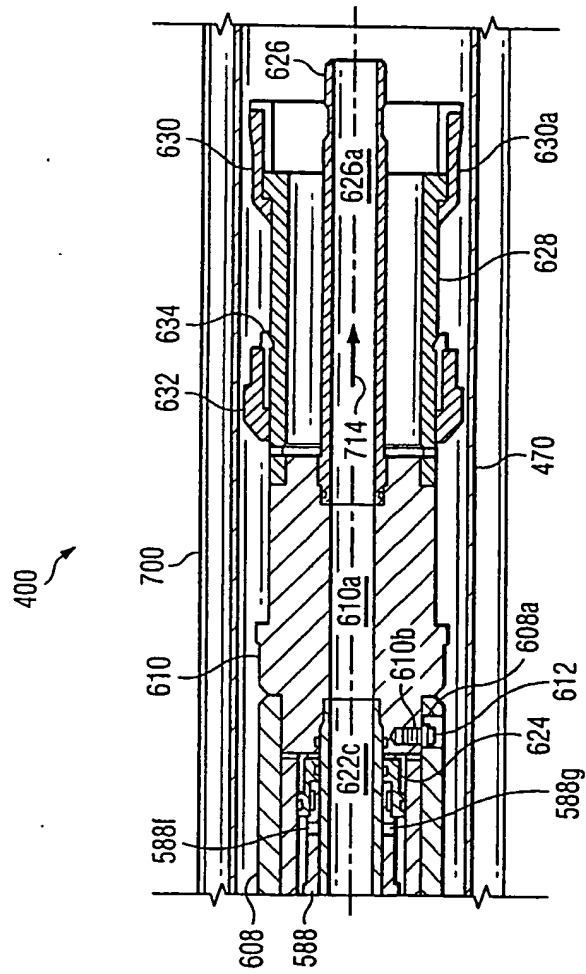


Fig. 34l



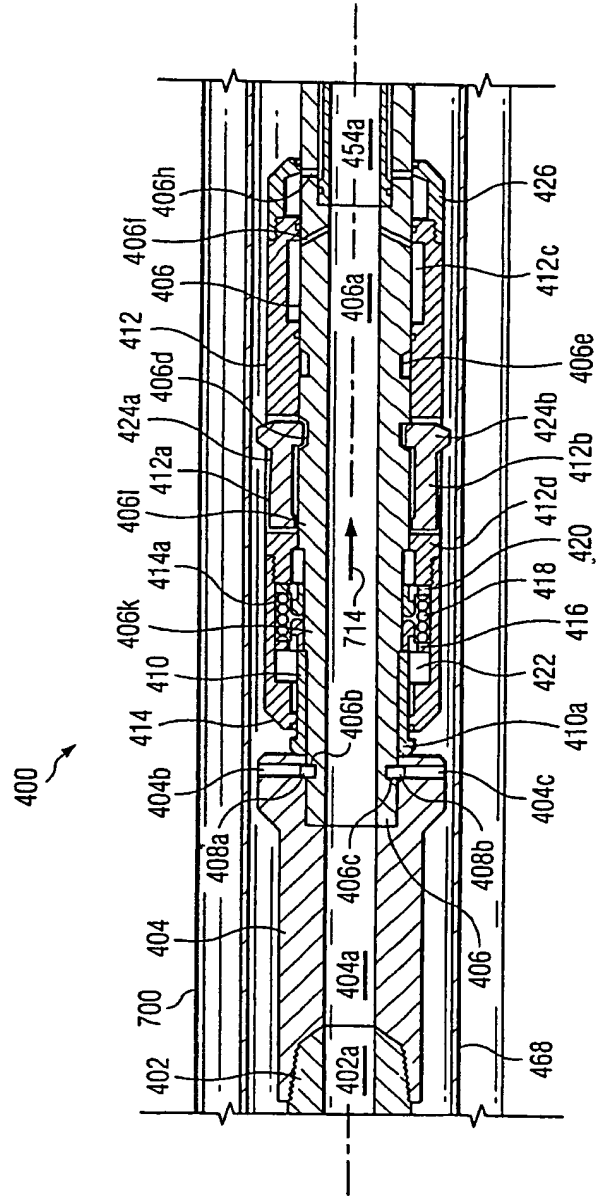


Fig. 35a

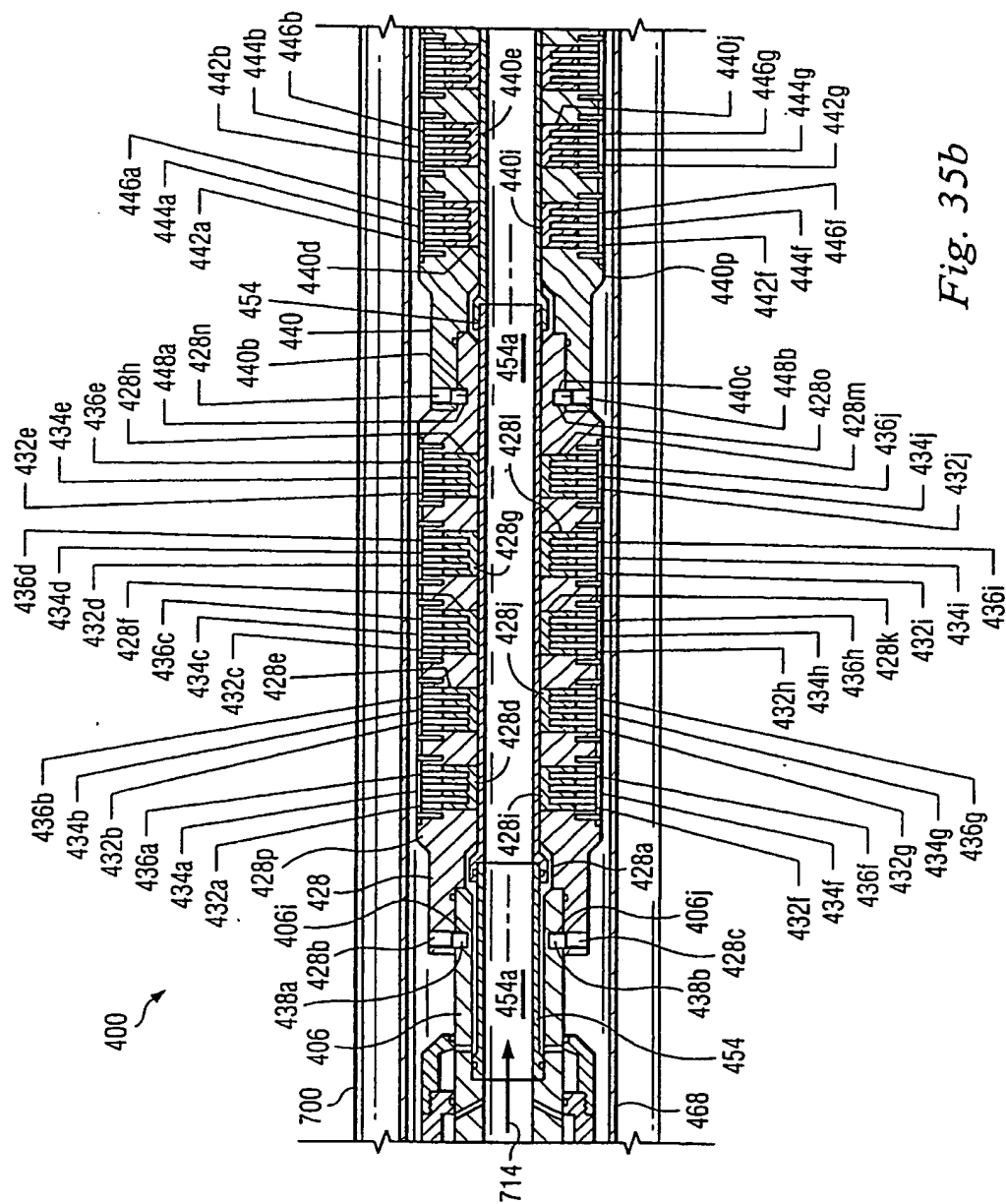
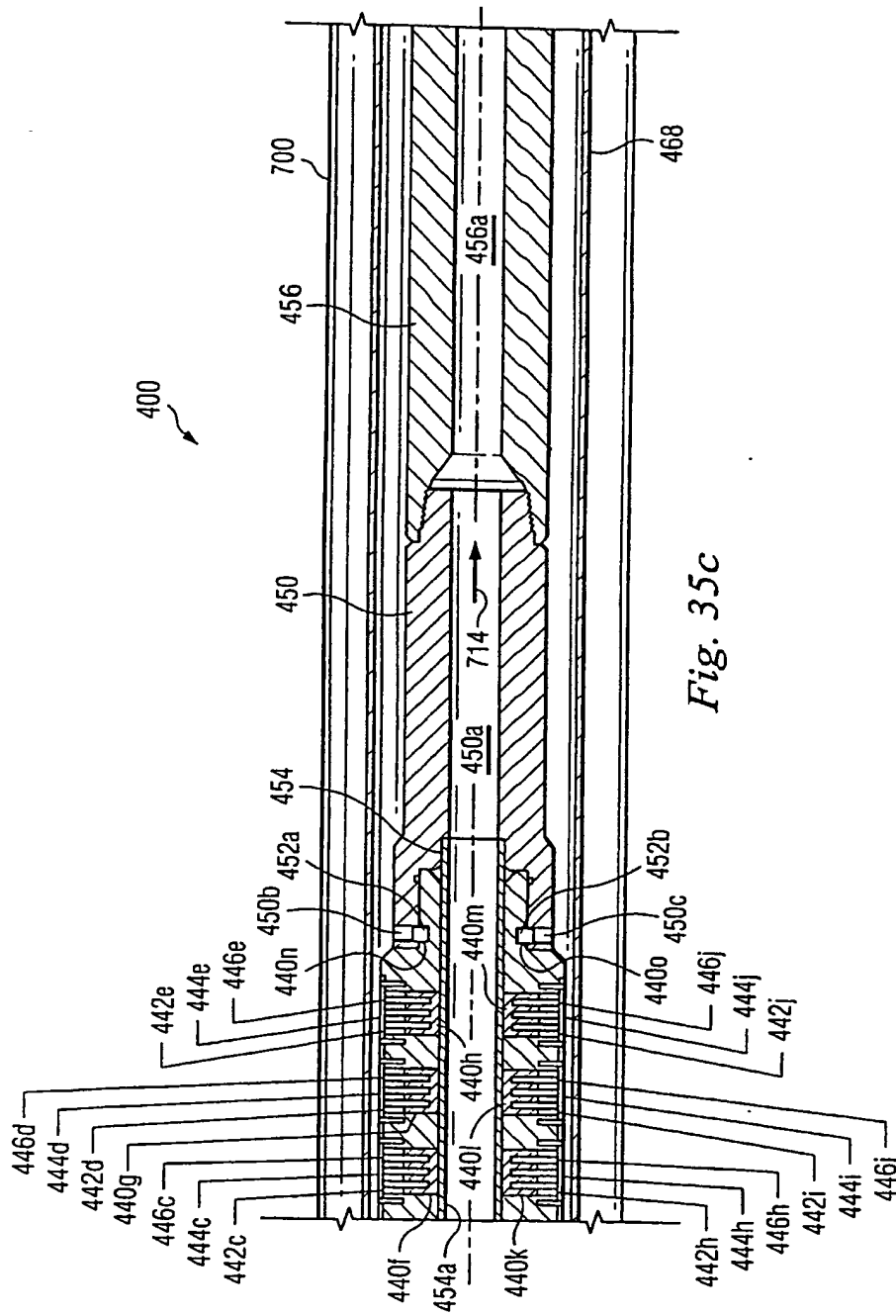


Fig. 35b



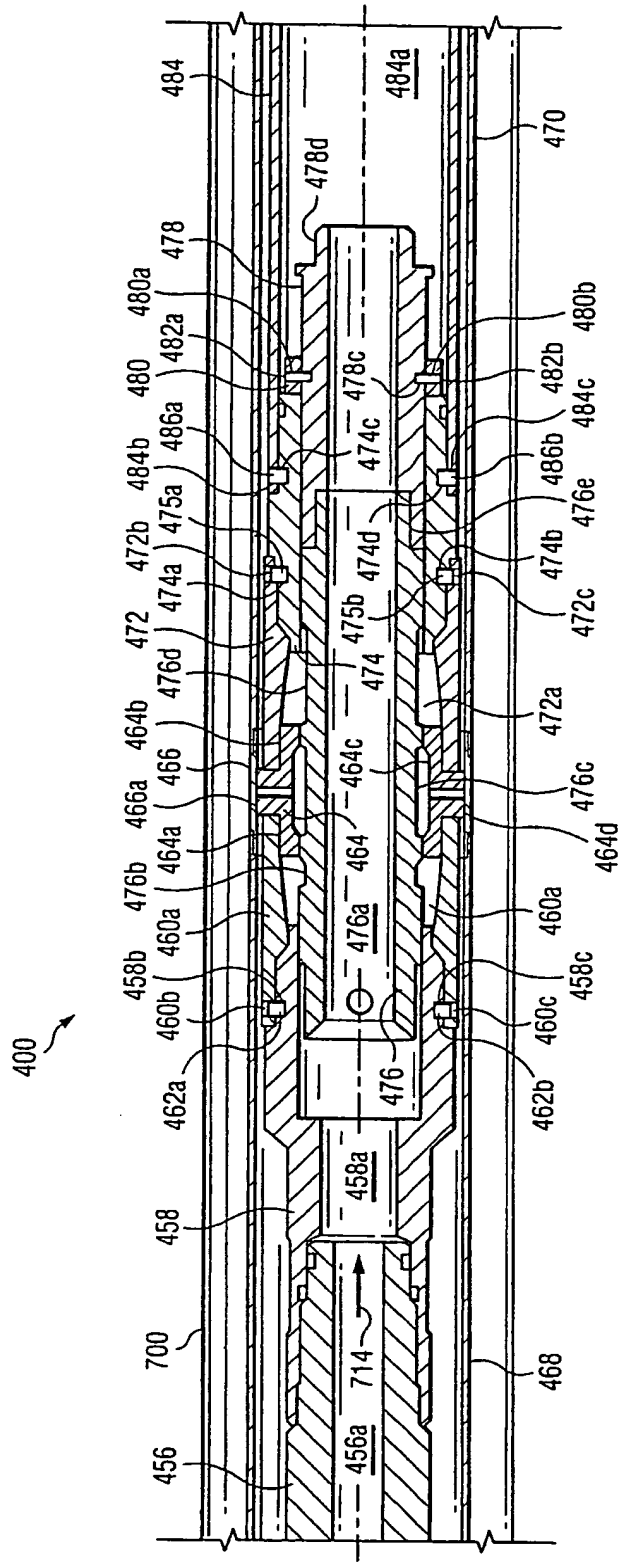


Fig. 35d

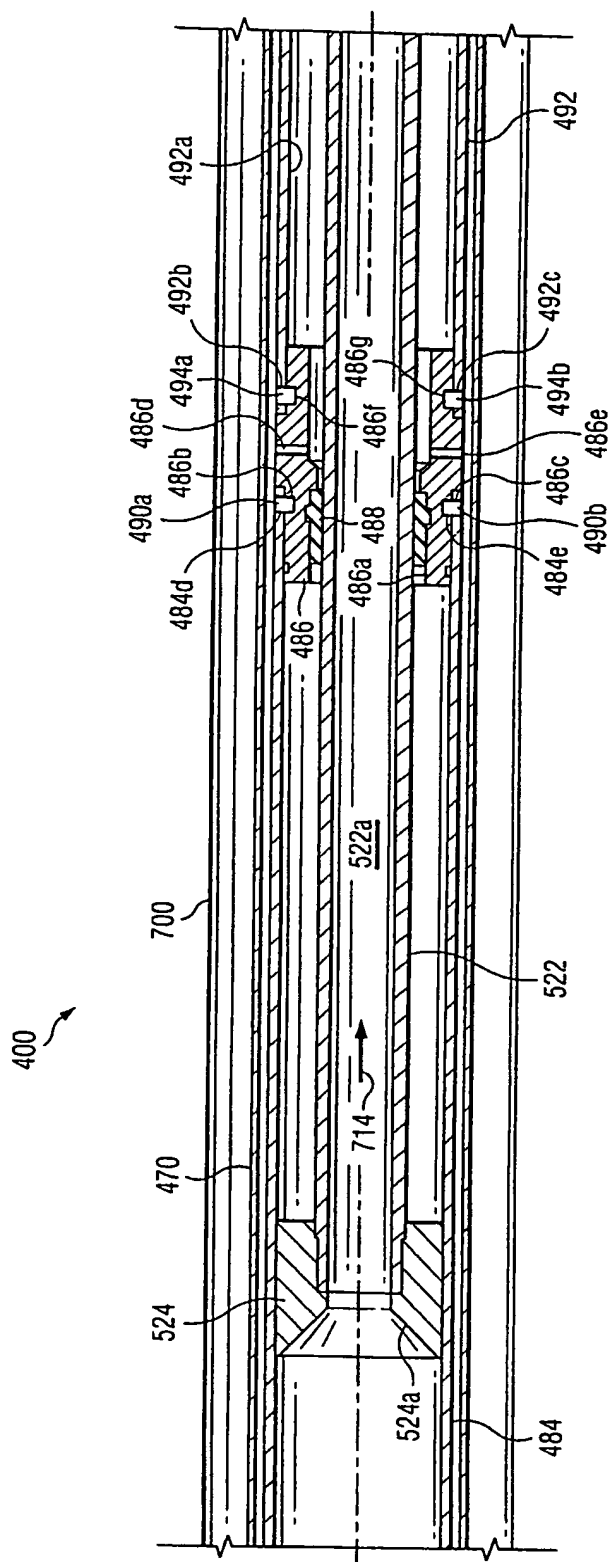


Fig. 35e

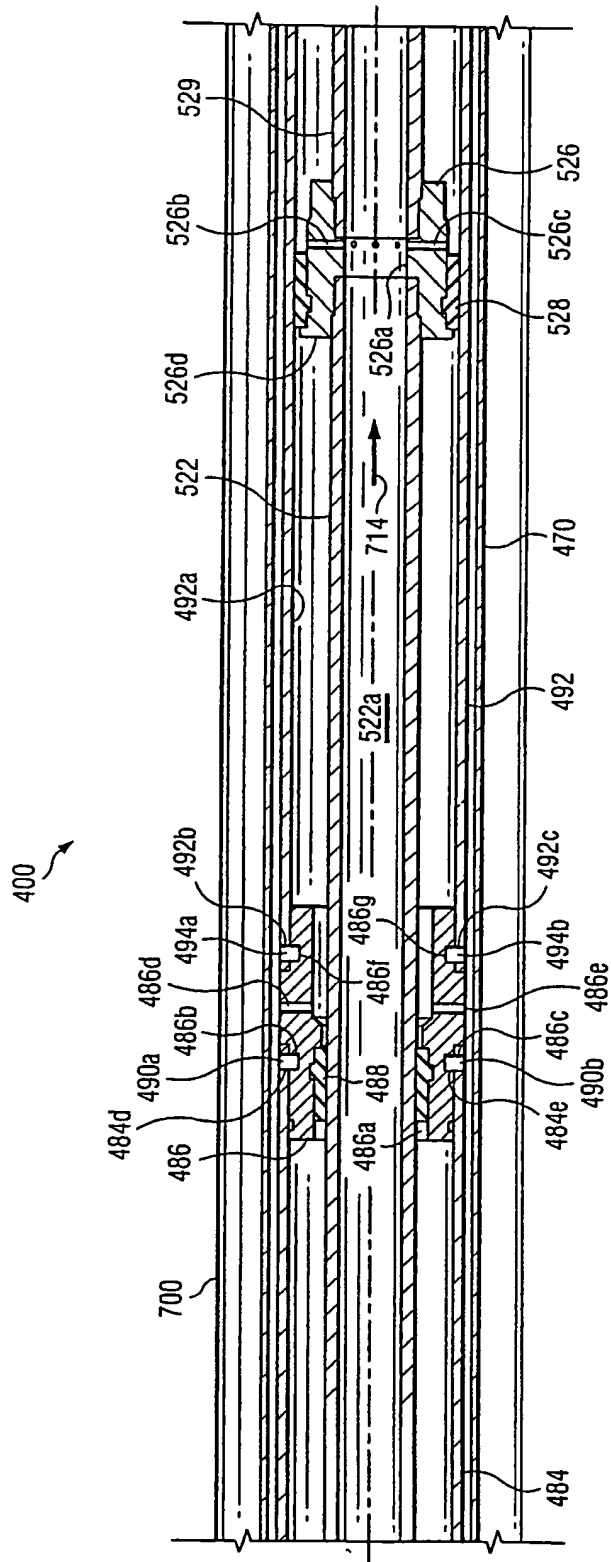


Fig. 35f

400

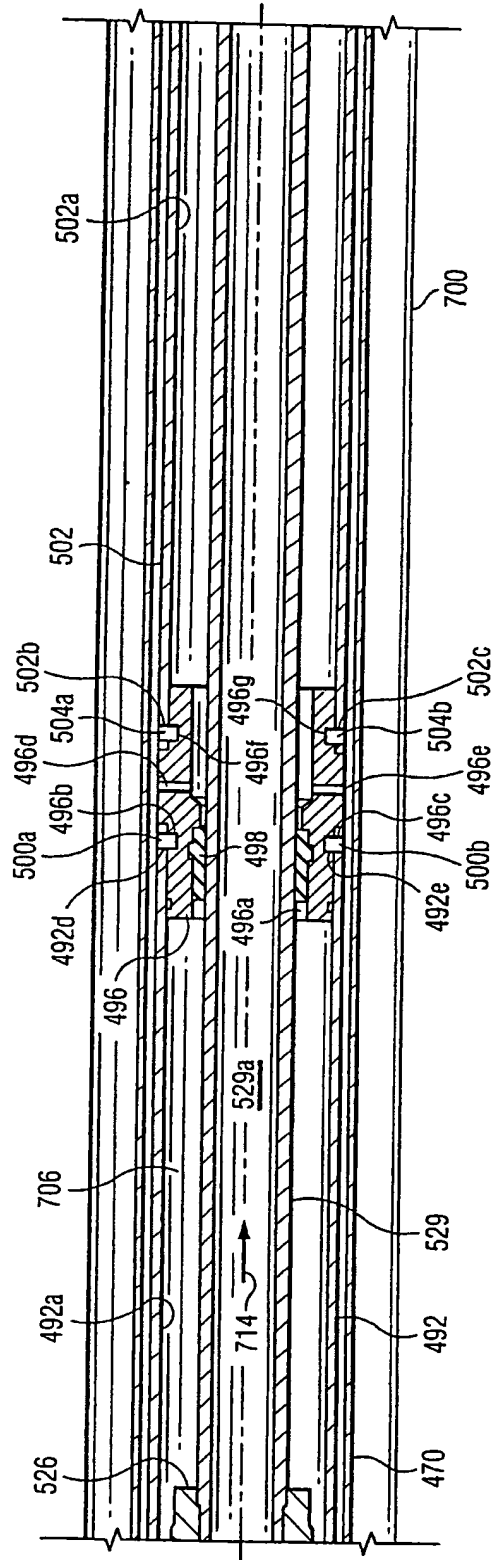


Fig. 35g

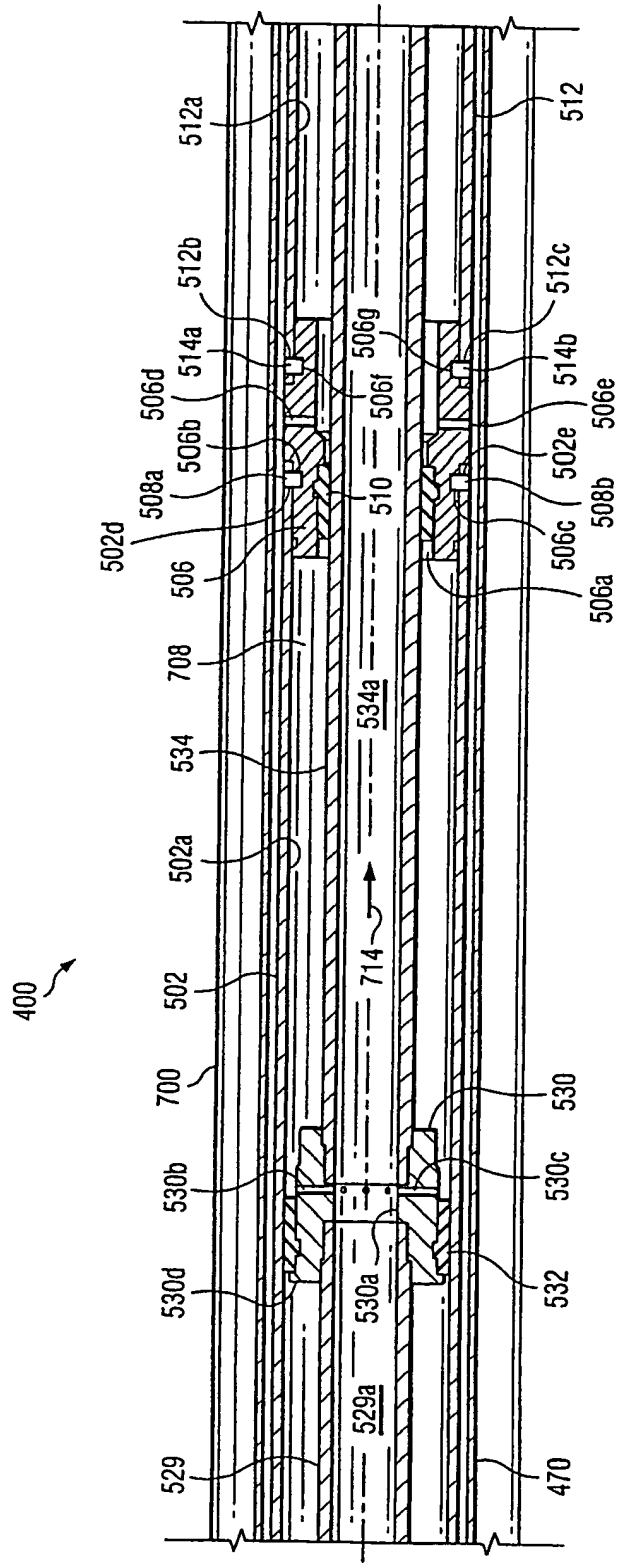


Fig. 35h



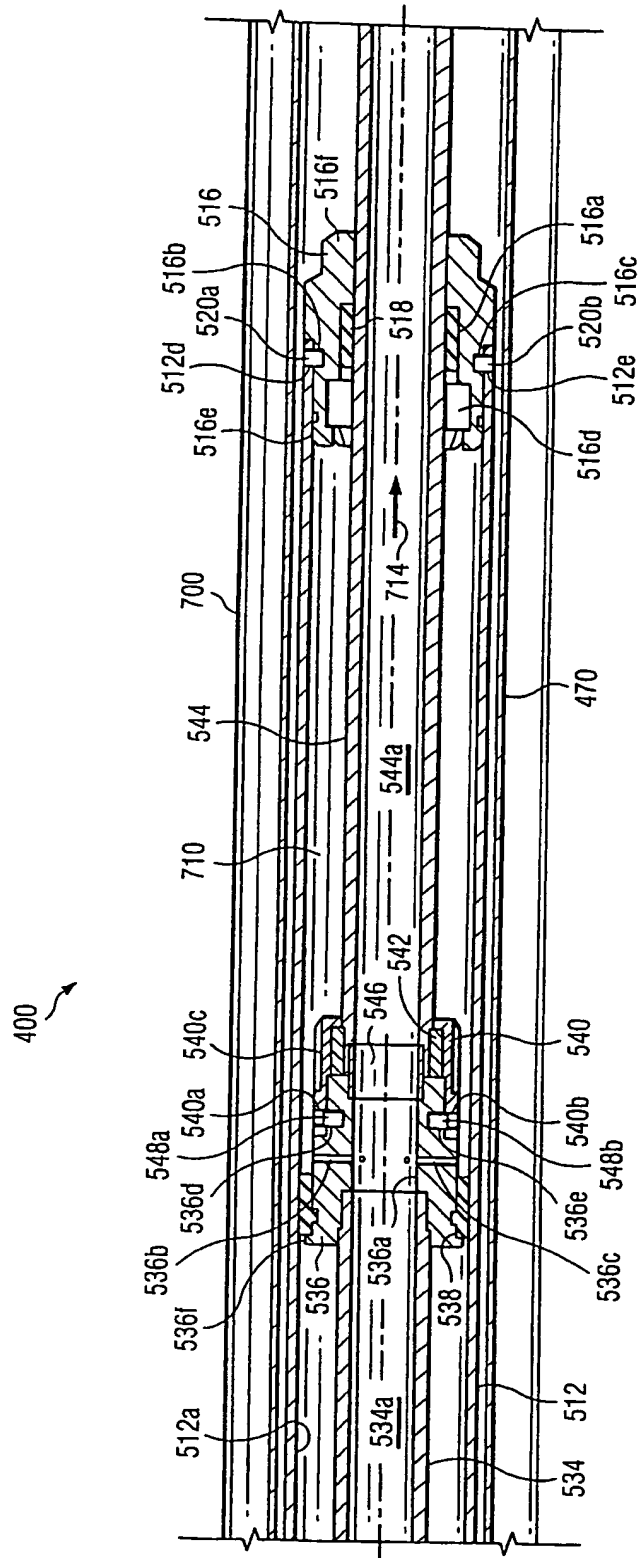


Fig. 35i

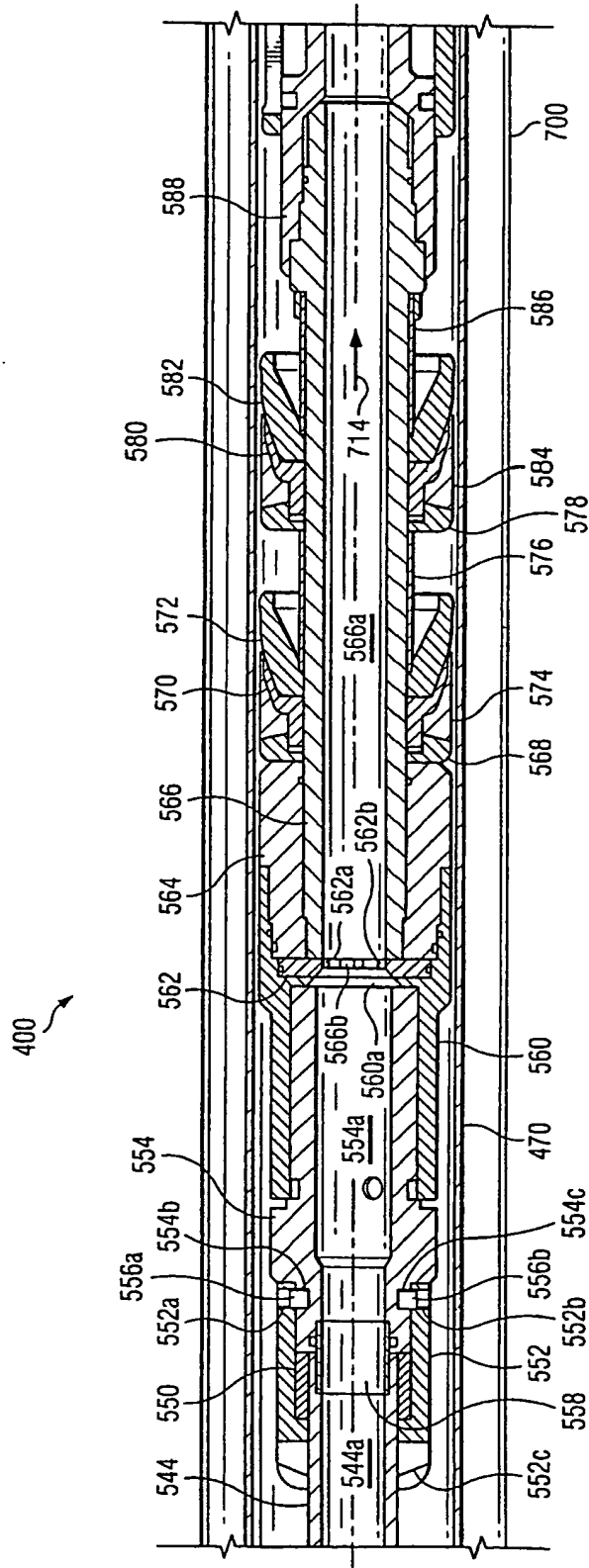


Fig. 35j



Fig. 35k

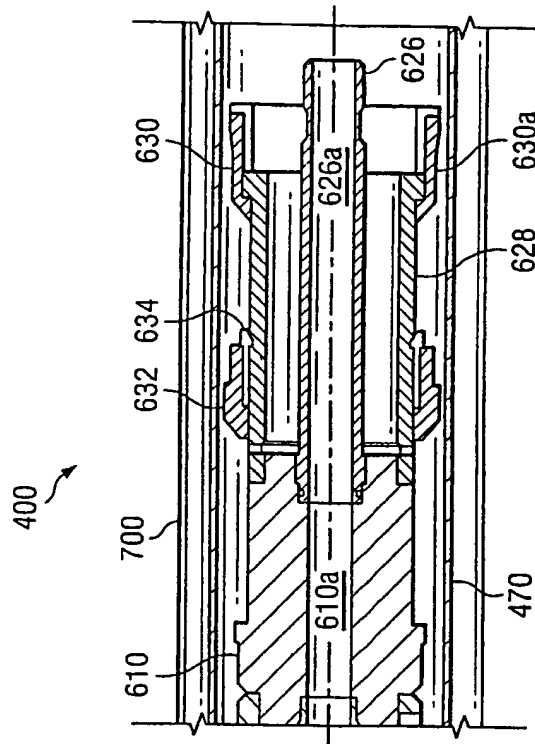


Fig. 35l

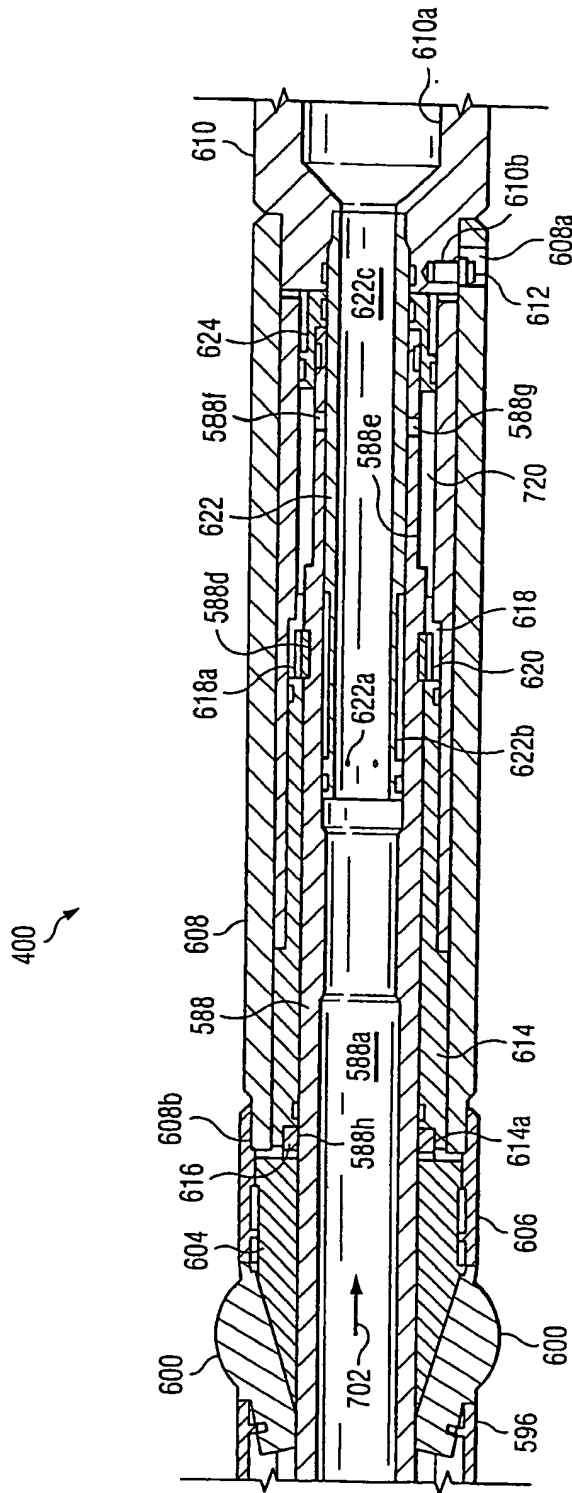


Fig. 36a

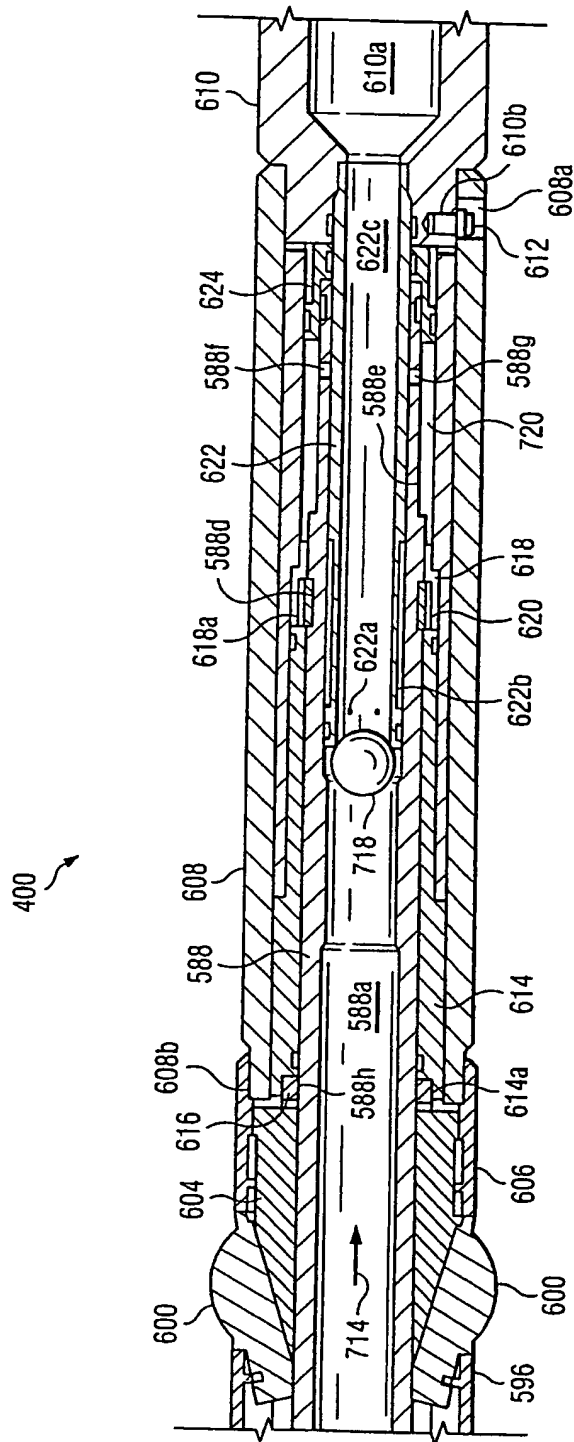


Fig. 36b

**MONO DIAMETER WELLBORE CASING****Cross Reference To Related Applications**

- 5 The present application claims the benefit of the filing dates of: (1) U.S. provisional patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on 11/12/2001, (2) U.S. provisional patent application serial no. 60/339,013, attorney docket no. 88, filed on 11/12/01 (3) U.S. provisional patent application serial no. 60/363,829, attorney docket no. 25791.95, filed on 3/13/2002, (4) U.S. provisional
- 10 patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/2002 the disclosures of which are incorporated herein by reference.

- The present application is related to the following: (1) U.S. patent application serial no. 09/454,139, attorney docket no. 25791.03.02, filed on 12/3/1999, (2) U.S. patent
- 15 application serial no. 09/510,913, attorney docket no. 25791.7.02, filed on 2/23/2000, (3) U.S. patent application serial no. 09/502,350, attorney docket no. 25791.8.02, filed on 2/10/2000, (4) U.S. patent no. 6,328,113, (5) U.S. patent application serial no. 09/523,460, attorney docket no. 25791.11.02, filed on 3/10/2000, (6) U.S. patent application serial no. 09/512,895, attorney docket no. 25791.12.02, filed on 2/24/2000,
- 20 (7) U.S. patent application serial no. 09/511,941, attorney docket no. 25791.16.02, filed on 2/24/2000, (8) U.S. patent application serial no. 09/588,946, attorney docket no. 25791.17.02, filed on 6/7/2000, (9) U.S. patent application serial no. 09/559,122, attorney docket no. 25791.23.02, filed on 4/26/2000, (10) PCT patent application serial no. PCT/US00/18635, attorney docket no. 25791.25.02, filed on 7/9/2000, (11) U.S.
- 25 provisional patent application serial no. 60/162,671, attorney docket no. 25791.27, filed on 11/1/1999, (12) U.S. provisional patent application serial no. 60/154,047, attorney docket no. 25791.29, filed on 9/16/1999, (13) U.S. provisional patent application serial no. 60/159,082, attorney docket no. 25791.34, filed on 10/12/1999, (14) U.S. provisional patent application serial no. 60/159,039, attorney docket no. 25791.36, filed
- 30 on 10/12/1999, (15) U.S. provisional patent application serial no. 60/159,033, attorney docket no. 25791.37, filed on 10/12/1999, (16) U.S. provisional patent application serial no. 60/212,359, attorney docket no. 25791.38, filed on 6/19/2000, (17) U.S. provisional patent application serial no. 60/165,228, attorney docket no. 25791.39, filed on 11/12/1999, (18) U.S. provisional patent application serial no. 60/221,443, attorney

docket no. 25791.45, filed on 7/28/2000, (19) U.S. provisional patent application serial  
 no. 60/221,645, attorney docket no. 25791.46, filed on 7/28/2000, (20) U.S. provisional  
 patent application serial no. 60/233,638, attorney docket no. 25791.47, filed on  
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 5 docket no. 25791.48, filed on 10/2/2000, (22) U.S. provisional patent application serial  
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 10 no. 60/303,740, attorney docket no. 25791.61, filed on 7/6/2001, (26) U.S. provisional  
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 15 patent application serial no. 60/3318,386, attorney docket no. 25791.67.02, filed on  
 9/10/2001, (30) U.S. provisional patent application serial no. 60/326,886, attorney  
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 09/961,922, attorney docket no. 25791.69, filed on 10/3/2001, (32) U.S. provisional  
 patent application serial no. 60/338,996, attorney docket no. 25791.87, filed on  
 20 11/12/2001, (33) U.S. provisional patent application serial no. 60/339,013, attorney  
 docket no. 25791.88, filed on 11/12/2001, (34) U.S. utility patent application serial no.  
 10/016,467, attorney docket no. 25791.70, filed on 12/10/2001, (35) U.S. provisional  
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 12/27/2001, (36) U.S. provisional patent application serial no. 60/346,309, attorney  
 25 docket no. 25791.92, filed on 1/7/2002, (37) U.S. provisional patent application serial  
 no. 60/357,372, attorney docket no. 25791.71, filed on 2/15/2002, (38) U.S. provisional  
 patent application serial no. 60/363,829, attorney docket no. 25791.95, filed on  
 3/13/2002, (39) U.S. provisional patent application serial no. 60/372,048, attorney  
 docket no. 25791.93, filed on 4/12/2002, (40) U.S. provisional patent application serial  
 30 no. 60/372,632, attorney docket no. 25791.101, filed on 4/15/2002, (41) U.S.  
 provisional patent application serial no. 60/380,147, attorney docket no. 25791.104,  
 filed on 5/6/2002, (42) U.S. provisional patent application serial no. 60/383,917,  
 attorney docket no. 25791.89, filed on 5/29/2002, (43) U.S. provisional patent  
 application serial no. 60/387,486, attorney docket no. 25791.107, filed on 6/10/2002,



(44) U.S. provisional patent application serial no. 60/387,961, attorney docket no. 25791.108, filed on 6/12/2002, (45) U.S. provisional patent application serial no. 60/391,703, attorney docket no. 25791.90, filed on 6/26/2002, (46) U.S. provisional patent application serial no. 60/397,284, attorney docket no. 25791.106, filed on 7/19/2002, (47) U.S. provisional patent application serial no. 60/398,061, attorney docket no. 25791.110, filed on 7/24/2002, (48) U.S. provisional patent application serial no. 60/399,240, attorney docket no. 25791.111, filed on 7/29/2002, (49) U.S. provisional patent application serial no. 60/405,610, attorney docket no. 25791.119, filed on 8/23/2002, (50) U.S. provisional patent application serial no. 60/405,394, attorney docket no. 25791.120, filed on 8/23/2002, (51) U.S. provisional patent application serial no. 60/407,442, attorney docket no. 25791.125, filed on 8/30/2002, (52) U.S. provisional patent application serial no. 60/412,542, attorney docket no. 25791.102, filed on 9/20/2002, (53) U.S. provisional patent application serial no. 60/412,177, attorney docket no. 25791.117, filed on 9/20/2002, (54) U.S. provisional patent application serial no. 60/412,653, attorney docket no. 25791.118, filed on 9/20/2002, (55) U.S. provisional patent application serial no. 60/412,544, attorney docket no. 25791.121, filed on 9/20/2002, (56) U.S. provisional patent application serial no. 60/412,187, attorney docket no. 25791.128, filed on 9/20/2002, (57) U.S. provisional patent application serial no. 60/412,187, attorney docket no. 25791.127, filed on 9/20/2002, (58) U.S. provisional patent application serial no. 60/412,487, attorney docket no. 25791.127, filed on 9/20/2002, (59) U.S. provisional patent application serial no. 60/412,488, attorney docket no. 25791.114, filed on 9/20/2002, and (60) U.S. provisional patent application serial no. 60/412,371, attorney docket no. 25791.129, filed on 9/20/2002, (61) PCT Patent Application No. PCT/US02\_\_\_\_\_, attorney docket no. 25791.87.02, filed on 11/11/02 and (62) PCT Patent Application No. PCT/US02\_\_\_\_\_, attorney docket no. 25791.88.02, filed on 11/11/02 the disclosures of which are incorporated herein by reference.

30

### Background Of The Invention

This invention relates generally to oil and gas exploration, and in particular to forming and repairing wellbore casings to facilitate oil and gas exploration.

- Conventionally, when a wellbore is created, a number of casings are installed in the borehole to prevent collapse of the borehole wall and to prevent undesired outflow of drilling fluid into the formation or inflow of fluid from the formation into the borehole.
- 5 The borehole is drilled in intervals whereby a casing which is to be installed in a lower borehole interval is lowered through a previously installed casing of an upper borehole interval. As a consequence of this procedure the casing of the lower interval is of smaller diameter than the casing of the upper interval. Thus, the casings are in a nested arrangement with casing diameters decreasing in downward direction. Cement
- 10 annuli are provided between the outer surfaces of the casings and the borehole wall to seal the casings from the borehole wall. As a consequence of this nested arrangement a relatively large borehole diameter is required at the upper part of the wellbore. Such a large borehole diameter involves increased costs due to heavy casing handling equipment, large drill bits and increased volumes of drilling fluid and drill cuttings.
- 15 Moreover, increased drilling rig time is involved due to required cement pumping, cement hardening, required equipment changes due to large variations in hole diameters drilled in the course of the well, and the large volume of cuttings drilled and removed.
- 20 The present invention is directed to overcoming one or more of the limitations of the existing procedures for forming and/or repairing wellbore casings.

#### Summary of the Invention

- 25 According to one aspect of the present invention, an apparatus for radially expanding and plastically deforming an expandable tubular member is provided that includes a float shoe adapted to mate with an end of the expandable tubular member, an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular
- 30 member or collapsed to a smaller outside dimension, an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, and a support member coupled to the locking device.

According to another aspect of the present invention, a method for radially expanding and plastically deforming an expandable tubular member within a borehole is provided that includes positioning an adjustable expansion mandrel within the expandable  
5 tubular member, supporting the expandable tubular member and the adjustable expansion mandrel within the borehole, lowering the adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, and displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n  
10 portions of the expandable tubular member.

According to another aspect of the present invention, a method for forming a mono diameter wellbore casing is provided that includes positioning an adjustable expansion mandrel within a first expandable tubular member, supporting the first expandable  
15 tubular member and the adjustable expansion mandrel within a borehole, lowering the adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular  
20 member within the borehole, positioning the adjustable expansion mandrel within a second expandable tubular member, supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member, lowering the adjustable expansion mandrel out of the second expandable tubular member, increasing the outside  
25 dimension of the adjustable expansion mandrel, and displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the borehole.

30 According to another aspect of the present invention, an apparatus for radially expanding and plastically deforming an expandable tubular member is provided that includes a float shoe adapted to mate with an end of the expandable tubular member, an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular

member or collapsed to a smaller outside dimension, an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, a support member coupled to the locking device, and a sealing member for sealingly engaging the expandable tubular member adapted to define a pressure chamber above the adjustable expansion mandrel during radial expansion of the expandable tubular member.

10 According to another aspect of the present invention, a method for radially expanding and plastically deforming an expandable tubular member within a borehole is provided that includes positioning an adjustable expansion mandrel within the expandable tubular member, supporting the expandable tubular member and the adjustable expansion mandrel within the borehole, lowering the adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to radially expand and plastically deform n portions of the expandable tubular member within the borehole, and pressurizing an interior region of the expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the expandable tubular member within the borehole.

25 According to another aspect of the present invention, a method for forming a mono diameter wellbore casing is provided that includes positioning an adjustable expansion mandrel within a first expandable tubular member, supporting the first expandable tubular member and the adjustable expansion mandrel within a borehole, lowering the adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member m times to radially expand and plastically deform m portions of the first expandable tubular member within the borehole, pressurizing an interior region of the first expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the first expandable tubular member within the borehole, positioning the adjustable expansion mandrel within a second expandable tubular

member, supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member, lowering the adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member n times to radially expand and plastically deform n portions of the second expandable tubular member within the borehole, and pressurizing an interior region of the second expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the second expandable tubular member within the borehole.

According to another aspect of the present invention, an apparatus for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole is provided that includes a float shoe adapted to mate with an end of the expandable tubular member, a drilling member coupled to the float shoe adapted to drill the borehole, an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension, an actuator coupled to the adjustable expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, and a support member coupled to the locking device.

According to another aspect of the present invention, a method for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole is provided that include positioning an adjustable expansion mandrel within the expandable tubular member, coupling a drilling member to an end of the expandable tubular member, drilling the borehole using the drilling member, positioning the adjustable expansion mandrel and the expandable tubular member within the drilled borehole, lowering the adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, and displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member n times to

radially expand and plastically deform  $n$  portions of the expandable tubular member within the drilled borehole.

5 According to another aspect of the present invention, a method for forming a mono diameter wellbore casing within a borehole is provided that includes positioning an adjustable expansion mandrel within a first expandable tubular member, coupling a drilling member to an end of the first expandable tubular member, drilling a first section of the borehole using the drilling member, supporting the first expandable tubular member and the adjustable expansion mandrel within the drilled first section of the borehole, lowering the adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member  $m$  times to radially expand and plastically deform  $m$  portions of the first expandable tubular member within the drilled first section of the borehole, positioning the adjustable expansion mandrel within a second expandable tubular member, coupling the drilling member to an end of the second expandable tubular member, drilling a second section of the borehole using the drilling member, supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member within the second drilled section of the borehole, lowering the adjustable expansion mandrel out of the second expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, and displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member  $n$  times to radially expand and plastically deform  $n$  portions of the second expandable tubular member within the drilled second section of the borehole.

30 According to another aspect of the present invention, an apparatus for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole is provided that includes a float shoe adapted to mate with an end of the expandable tubular member, a drilling member coupled to the float shoe adapted to drill the borehole, an adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a larger outside dimension for radial expansion of the expandable tubular member or collapsed to a smaller outside dimension, an actuator coupled to the adjustable

expansion mandrel adapted to controllably displace the adjustable expansion mandrel relative to the expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, a support member coupled to the locking device, and a sealing member for sealing engaging the expandable tubular member adapted to define a pressure chamber above the adjustable expansion mandrel during the radial expansion of the expandable tubular member.

According to another aspect of the present invention, a method for drilling a borehole within a subterranean formation and then radially expanding and plastically deforming an expandable tubular member within the drilled borehole is provided that includes positioning an adjustable expansion mandrel within the expandable tubular member, coupling a drilling member to an end of the expandable tubular member, drilling the borehole using the drilling member, positioning the adjustable expansion mandrel and the expandable tubular member within the drilled borehole, lowering the adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the expandable tubular member  $n$  times to radially expand and plastically deform  $n$  portions of the expandable tubular member within the drilled borehole, and pressuring an interior portion of the expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the expandable tubular member within the drilled borehole.

According to another aspect of the present invention, a method for forming a mono diameter wellbore casing within a borehole is provided that includes positioning an adjustable expansion mandrel within a first expandable tubular member, coupling a drilling member to an end of the first expandable tubular member, drilling a first section of the borehole using the drilling member, supporting the first expandable tubular member and the adjustable expansion mandrel within the drilled first section of the borehole, lowering the adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the first expandable tubular member  $m$  times to radially expand and plastically deform  $m$  portions of the first expandable tubular member within the drilled first section of the borehole, pressuring

an interior portion of the first expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the first expandable tubular member within the first drilled section of the borehole, positioning the adjustable expansion mandrel within a second expandable tubular member, 5 coupling the drilling member to an end of the second expandable tubular member, drilling a second section of the borehole using the drilling member, supporting the second expandable tubular member and the adjustable expansion mandrel within the borehole in overlapping relation to the first expandable tubular member within the second drilled section of the borehole, lowering the adjustable expansion mandrel out 10 of the second expandable tubular member, increasing the outside dimension of the adjustable expansion mandrel, displacing the adjustable expansion mandrel upwardly relative to the second expandable tubular member  $n$  times to radially expand and plastically deform  $n$  portions of the second expandable tubular member within the drilled second section of the borehole, and pressuring an interior portion of the second 15 expandable tubular member above the adjustable expansion mandrel during the radial expansion and plastic deformation of the second expandable tubular member within the drilled second section of the borehole.

According to another aspect of the present invention, an apparatus for radially 20 expanding and plastically deforming an expandable tubular member is provided that includes a float shoe adapted to mate with an end of the expandable tubular member, a first adjustable expansion mandrel coupled to the float shoe adapted to be controllably expanded to a first larger outside dimension for radial expansion of the expandable tubular member or collapsed to a first smaller outside dimension, a second adjustable 25 expansion mandrel coupled to the first adjustable expansion mandrel adapted to be controllably expanded to a second larger outside dimension for radial expansion of the expandable tubular member or collapsed to a second smaller outside dimension, an actuator coupled to the first and second adjustable expansion mandrels adapted to controllably displace the first and second adjustable expansion mandrels relative to the 30 expandable tubular member, a locking device coupled to the actuator adapted to controllably engage the expandable tubular member, and a support member coupled to the locking device. The first larger outside dimension of the first adjustable expansion mandrel is larger than the second larger outside dimension of the second adjustable expansion mandrel.



According to another aspect of the present invention, a method for radially expanding and plastically deforming an expandable tubular member within a borehole is provided that includes positioning first and second adjustable expansion mandrels within the expandable tubular member, supporting the expandable tubular member and the first and second adjustable expansion mandrels within the borehole, lowering the first adjustable expansion mandrel out of the expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform a lower portion of the expandable tubular member, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the expandable tubular member, decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, and displacing the second adjustable expansion mandrel upwardly relative to the expandable tubular member to radially expand and plastically deform portions of the expandable tubular member above the lower portion of the expandable tubular member. The outside dimension of the first adjustable expansion mandrel is greater than the outside dimension of the second adjustable expansion mandrel.

According to another aspect of the present invention, a method for forming a mono diameter wellbore casing is provided that includes positioning first and second adjustable expansion mandrels within a first expandable tubular member, supporting the first expandable tubular member and the first and second adjustable expansion mandrels within a borehole, lowering the first adjustable expansion mandrel out of the first expandable tubular member, increasing the outside dimension of the first adjustable expansion mandrel, displacing the first adjustable expansion mandrel upwardly relative to the first expandable tubular member to radially expand and plastically deform a lower portion of the first expandable tubular member, displacing the first adjustable expansion mandrel and the second adjustable expansion mandrel downwardly relative to the first expandable tubular member, decreasing the outside dimension of the first adjustable expansion mandrel and increasing the outside dimension of the second adjustable expansion mandrel, displacing the second adjustable expansion mandrel upwardly relative to the first expandable tubular member

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